

A Review of the Genus *Telmatogeton* Schiner, with Descriptions of three new Hawaiian Species (Diptera: Tendipedidae)

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INTRODUCTION

The genus *Telmatogeton* was proposed in 1866 by Schiner, who two years later described the first included species, *Telmatogeton sancti-pauli*, from adults and a remarkable pupa collected on St. Paul Island in the Indian Ocean during the voyage of the *Novara*. In 1900 Coquillett described *Telmatogeton alaskensis* from adults from Alaska. Johannsen (1905) gave a translation of Schiner's description of *Telmatogeton* and figures of *sancti-pauli*, and reprinted Coquillett's description of *alaskensis*. Kieffer in 1911 erected the allied genus *Paraclunio* for a new marine species, *trilobatus*, from California. In 1913 Terry founded the genus *Charadromyia* for two species from the Hawaiian Islands: *torrenticola*, of which the immature stages were described and life history notes were given, the species living in swift mountain streams; and *abnormis*, from adults only, the habitat of which was not given. Terry noted the close relationship between the Hawaiian species and *Telmatogeton*, especially in the peculiar truncated pupa, but in view of Schiner's incorrect description of the adult, Terry was led to place his species in a separate genus. Kieffer (1914) described two new marine tendipedids, *Paraclunio fuscipennis* and *P. minor*, from the Atlantic coast of South Africa. However Malloch (1915) placed Kieffer's *trilobatus* as a synonym of *alaskensis* Coquillett, which he transferred to the genus *Paraclunio*. In 1919 Kieffer, disagreeing with Malloch's action, held that *Paraclunio trilobatus* and *Telmatogeton alaskensis* belonged to different genera. In 1920 Kieffer proposed a new genus *Trissoclunio* for the two South African species described in 1914. Edwards in 1926 commented on *Paraclunio trilobatus* and *Trissoclunio fuscipennis* and in 1928 published in *Konowia* a critical review of the genus *Telmatogeton* and its close relatives. After examining type material Edwards showed that Schiner's description of the palpi of *Telmatogeton* as four-segmented was incorrect, these actually being incompletely two-segmented, in this respect resembling *Paraclunio* and *Charadromyia*. In comparing Cape Town material of *Trissoclunio fuscipennis* with co-types of *Telmatogeton sancti-pauli*

Edwards could find no differences. After examining a series of British Columbia specimens as well as a co-type from Alaska of *alaskensis*, and a co-type of *trilobatus* from California, Edwards believed that both species should be placed in *Parachunio*. He also indicated that *Telmatogeton minus* (*minor* Kieffer) might be a small form of *sancti-pauli*, and mentioned an undescribed marine species from Chiloe Island, Chile. Saunders (1928) gave a detailed description of *Parachunio alaskensis* with excellent figures, including the immature stages and detailed life history notes showing that this species is marine.

Beginning with Edwards' description of two marine species, *Telmatogeton trochanteratum* and *simplicipes* in 1931 from Chile, the geographical range of *Telmatogeton* was soon extended throughout the Pacific Ocean. Tokunaga described two new marine species from Japan, *japonicus* in 1933 and *pacificus* in 1935. Hesse at Cape Town, South Africa, in 1934 gave a detailed description of the adult, larva and pupa and ecological notes for a marine species distinct from *sancti-pauli* which he doubtfully referred to *Telmatogeton minor*. In 1935 Edwards described *Telmatogeton pusillum* from adults captured at light near the sea in the Marquesas Islands in the south central Pacific. Tokunaga gave a very complete account of the early stages of *Telmatogeton japonicus* in 1935. Womersley (1936) described *Telmatogeton australicus*, including immature stages, from a South Australian reef, and gave biological notes.

With the exception of Illingworth's (1931) record of *Charadromyia torrenticola* from the Waiahole ditch, Oahu, no notes on Hawaiian *Telmatogeton* appeared until Williams published his biological notes on Hawaiian Chironomidae in 1944. In this paper notes were given on *Telmatogeton pusillum* Edwards from the coasts of Oahu, *abnormis* (Terry), a freshwater species, was listed from Kauai, *torrenticola* (Terry) from the rapid streams, waterfalls, and flumes of Hawaii, Maui, and Molokai, and notes were given on two additional un-named freshwater species from Oahu (sp. #1) and Kauai (sp. #2). In an excellent plate, morphological details were given of various stages of some of these species.

In the present paper it is proposed to clarify the status of the species known to occur in the Hawaiian Islands, with the description of three new species and the presentation of biological notes. Keys have been constructed to the adults and the immature stages (when known) to include all known species from the world, although in the absence of some foreign material and because of brief descriptions of some of the species, the writer has been hindered in the use of most convenient characters and it may well prove that several of the described species are synonymous.

The types of the species described as new are deposited in the Bernice P. Bishop Museum at Honolulu. Paratypes have been furnished the U. S. National Museum, the British Museum, the Harvard Museum of Comparative Zoology, the California Academy of Sciences, the South African Museum, and the South Australian Museum.

Genus TELMATOGETON Schiner 1866

Telmatogeton Schiner, Verh. Zool. bot. Ges. Wien, 16:931, 1866; Novara Reise Zool., 2:25, 1868 (genus redescribed, *T. sancti-pauli*, sp. n.); Edwards, Konowia, 7:234, 1928 (syn.: *Charadromyia* Terry, *Trissoclunio* Kieffer, new synonymy; *Paraclunio* Kieffer distinct from *Telmatogeton*).

Charadromyia Terry, Proc. Haw. Ent. Soc., 2:292, 1913 (Hawaiian Is.; 2 freshwater species).

Trissoclunio Kieffer, Ann. S. Afr. Mus., 17:523, 1920 (genus erected for *fuscipennis*, *minor*; S. Africa).

GENOTYPE.—*Telmatogeton sancti-pauli* Schiner.

Adult.—Coloration generally brown to black, mesonotum usually pruinose, wings smoky pale brown to dark grayish black. Head small, deeply set under anterior margin of the arched mesonotum; eyes round, widely separated by the deeply excavated front, ocelli absent; a small black pigment spot, function unknown, situated on postgena behind each eye. Antennae seven-segmented and non-plumose in both sexes; basal segment (scape) large, second segment elongated, third to sixth subspherical, seventh elongated and generally tapering toward a nipple-like tip; palpi two-segmented, often incompletely so. Pronotum widely divided, the lobes small; mesonotum arched, robust; scutellum convex; postscutellum prominent, elongated. Wings well developed in both sexes, generally extending beyond tip of abdomen in male, not quite reaching tip of abdomen in female; broad, anal angle about 90°; subcosta parallel to costa, radial veins strong and setigerous R_1 short, R_{2+3} absent, R_{4+5} extending nearly to wing-tip, r-m long and oblique; M reaching wing margin posterior to wing-tip, Cu usually forks about level of r-m which is generally just proximad of middle of wing; Cu_1 nearly straight, Cu_2 strongly curved at tip, anal veins short, not reaching wing-margin. Halteres large with a broad knob. Legs long and slender, the front femora often clavate at base, not enlarged or modified at tip; a small blunt, thumb-shaped, heavily sclerotized spur at base of each tibia which is attached to a hyaline sheath arising at the end of the femur on flexor side; apical tibial spines small, single or double; basitarsus elongate, usually shorter on mid-leg, following two segments progressively much shorter, third and fourth subequal, fifth segment slightly longer than fourth, prominently trilobed; claws of female simple, long and sharp; of male typically bifid into a sharp inner arm and a knobbed pectinate outer arm, though extreme modifications of male claws may occur; empodium large and plumose; a lanceolate membranous lamella, probably analogous with the pulvilli, arising from the base of each claw, as well as one or more long setae in most species. Abdomen long and slender; segment eight of female markedly triangularly tapering and laterally compressed, cerci prominent; tip of male abdomen generally rotated between segments seven and eight to a maximum of 90° sinistrad or dextrad, genitalia

small, simple, basistyles broad, dististyles oval and flattened, without appendages, phallosome conical, dorsally directed, anal tube often prominent at base of eighth tergite.

Larva.—Elongate and cylindrical, generally pale greenish in first instars, darkening to olivaceous when mature. Head brown, heavily sclerotized, oval, eye-spots present, antennae (fig. 3d) small, large basal segment bearing apically three minute distal segments and a biramous membranous Lauterborn organ; mandibles (fig. 3b) large, dentated distally; maxillae (fig. 3e) simple, palp small and unsegmented; mentum (fig. 3g) broadly triangular, with a large median tooth and several smaller lateral teeth. Thorax with first segment larger than next two and bearing a bilobed pseudopod, each lobe crowned with many hooklets (fig. 3h) of varying sizes. Thoracic segments with imaginal leg-buds showing through integument laterally. Abdominal segments one to eight cylindrical and bare except for a few small setae; ninth segment rounded dorsally and bearing a pair of ventro-lateral pseudopods with several rows of stout curved hooks (fig. 3i) at apex; three short anal gills occasionally present.

Pupa.—Dark brownish to olivaceous in color; head ventral in position, adherent to thorax; antennal cases projecting latero-posteriorly over prothoracic lobes. Thorax rounding dorso-anteriorly, with a pair of prominent horn-shaped respiratory organs (fig. 6f) extending over head, position of spiracle variable, one-half to three-fourths way on lobe. Wing and leg cases free but appressed ventrally to body; scutellum transverse, postscutellum well defined as a posterior convex lobe about as broad as long. Halteres present as raised tubercles laterad of postscutellum. Abdomen eight-segmented, including a terminal obliquely truncated shield-shaped segment with a flattened dorso-posterior disc with emarginate dentated rim (fig. 6g). Preapical segments each with a narrow U-shaped sclerotized line along anterior and lateral margins of tergites and sternites; variable patches of shagreening present on some or all segments. Terminal abdominal disc divided at upper fourth to sixth by a slightly arched transverse suture, the sclerite above nearly perpendicular to body axis and without hairs on the marginal denticles; posterior sclerite sloping at about 45 to 60° with body axis, the emarginate rim with the denticles bearing tufts of fine amber hairs except at the posterior apex which forms two rather smooth lobes with a pair of curved posteriorly projecting spikes. The disc of the female pupa is usually more elongate, proportionately to the elongation of female genital segments of the female imago. In the male pupa (fig. 3c) the venter of the eighth segment bears two large appressed lobes containing the adult gonostyles, while in the female pupa there are in the same position a pair of small anterior lobes and a pair of large posterior lobes containing the developing ventral valves of ovipositor and the cerci respectively of the imago. The integument of the cephalothorax as well as the terminal abdominal disc, as readily shown in empty exuviae, is heavily sclerotized dark amber brown due to pebble-grained integumental thickenings or occasionally transverse wrinkles; the integument of the preapical abdominal segments except for the narrow U-shaped lines and occasional shagreened patches, is quite transparent.

Discussion.—The subfamily Clunioninae, of which *Telmatogeton* is representative, is distinguished from other Tendipedidae by the reduction of the pronotum to small lateral lobes, very short anepisternal suture, large front coxae, and absence of the cross-vein m-cu. The genus *Telmatogeton* belongs to a group of genera in which the fifth tarsal segment is deeply trilobed and the ovipositor of the female is conspicuously pointed. The other known genera with trilobed tarsi differ from *Telmatogeton* as follows: *Psammathiomys* Deby (Europe) and *Halirytus* Eaton (Ant-

arctic Region), wings very short or absent in both sexes; and *Paraclunio* Kieffer (West Coast of North America) with the front legs of the male modified, femora swollen, tibiae with a tubercle at base, and hairs of tibiae strong, sometimes flattened.

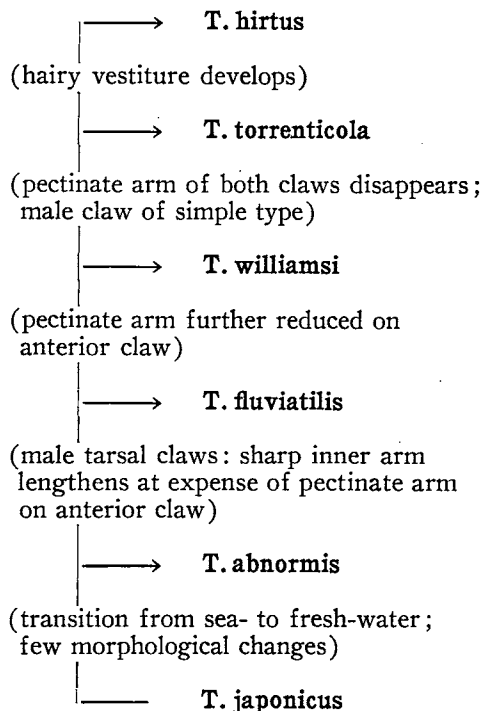
The immature stages of *Halirytus* and *Psammathiomyia* are not definitely known, although Deby (1889) described a larva and pupa of *Psammathiomyia pectinata*. Thienemann (1915) suggested that Deby had described a different larva which Edwards (1926) believed might be that of a tipulid. The immature stages of *Paraclunio alaskensis* were admirably described by Saunders (1928) and from a study of Dr. Saunders' descriptions and figures as well as examination of material kindly furnished by him, no readily discernible larval or pupal characters could be found separating this species from *Telmatogeton*. Although the extreme modifications of the legs of *P. alaskensis* would possibly give it separate generic status from *Telmatogeton*, all other characters point to its close relationship, probably with the "*japonicus* group" proposed below. As specimens of the genotype, *Paraclunio trilobatus* Kieffer, were not studied and existing descriptions are inadequate, the two genera are maintained as distinct for the present.

BIOLOGY

Notes have been given on the immature stages of seven species of *Telmatogeton*. Perhaps the best and most complete account of larval and pupal morphology and biology is that of Tokunaga (1935) for *T. japonicus* from Japan. Hesse (1934) also gave very excellent descriptions and a biological account of the immature stages of *T. sancti-pauli* and *T. minor* from South Africa. Terry (1913) and Williams (1944) also gave notes on the Hawaiian species, *T. pacificus* (as *T. pusillum*), *T. williamsi* and *T. fluviatilis* (together as *T. sp. #1*) and *T. hirtus* (as *T. sp. #2*). Womersley (1936) described the larva of *T. australicus* from South Australia.

As pointed out by previous workers, the genus *Telmatogeton* appears to be transitional between the marine and fresh-water environments. It is quite remarkable that of all the Clunioninae, only *Telmatogeton* has been found to breed elsewhere than on rocky sea coasts and then only in the rapid mountain streams of the Hawaiian Islands. Hesse stated that the marine *T. sancti-pauli* could withstand immersion in fresh-water for several days and Tokunaga was able to rear *T. japonicus* from the second instar in fresh-water. It appears then, that the Clunioninae, an exceptional insect group in many respects, went to the edges of the sea to live but only *Telmatogeton* retained its ability to live in fresh-water, and in the Hawaiian Islands, with numerous torrential mountain streams reaching the sea, these midges began working their way up the

waterfalls to their present home in the rushing torrents. As usual with an adaptable stock in an island group, various species were evolved in Hawaii; the more obvious evolutionary changes which have taken place can be shown simply in the following diagram:



The various fresh-water Hawaiian species appear to be closely related, forming a natural group for which Terry's name *Charadromyia* may be used.

The fresh-water Hawaiian species are apparently able to colonize only in water in rapid motion. No doubt this habit is due to an exceptionally acute demand by the immature stages for a combination of at least three factors: 1) high aeration, 2) constant moisture, and 3) freedom from waste materials. These factors are also met by the habitats on the spray-drenched coastal rocks selected by the marine species throughout the world. The fresh-water species are most often found at the falls and rapids of the larger mountain streams, where their whitish silken cases are usually built on the surface of boulders over which the water spills swiftly enough to prevent growth of thick deposits of algae. However in recent years most of the mountain streams have been tapped,

if not taken over entirely for the irrigation of the fields below. The adaptable *Telmatogeton* which were carried down in the irrigation water have been very successful in colonizing on the sides and bottoms of the rock-lined ditches and wooden flumes where the water runs swiftly and without interruption, even in the lowland sugar cane fields.

Habits of the adults.—The adult *Telmatogeton* are rather short-lived; Tokunaga gives 20 hours for *japonicus*. Consequently the light-colored newly-emerged adults immediately begin their reproductive functions. Hesse states that the eggs are already well-developed in the female pupae of *T. minor*; that in this species and in *sancti-pauli* the short adult life-span is engaged mainly in the copulatory function and oviposition, and that the adults are not known to feed. The writer has observed that the Hawaiian species become gravid while in the pupal stage. The adults are positively phototropic and the powers of flight, considered feeble by Hesse, are believed to be greater by Tokunaga who took numbers of *japonicus* at light, 600 meters from their breeding place. The writer has also taken *T. pacificus* and *japonicus* in light traps several hundred yards inland, though certainly they were assisted in these flights by strong on-shore winds. *T. williamsi* and *fluvialis* must not be strong fliers, as these distinct species have not been taken outside the streams and flumes of their respective ranges in the Waianae and Koolau mountains of Oahu, though separated by a lowland of only a few miles width.

The adults of most marine species are generally nocturnal, the peak of the emergence coming just after dusk, and the young adults soon begin their characteristic rapid "scampering" over the rocks, the males actively seeking out the females for mating. These scampering adults are most often found at the highest prominence of the spray-drenched rocks, on the side facing the sea. The scampering motion is a combination of half-running, half-flying, with the wings fluttering; on the advent of approaching waves, some adults take flight momentarily, but others in more sheltered pits and crevices in the rocks hold on flattened to the rock with legs widely extended crab-like, and seem none the worse for their wetting. This extreme water repellence, necessitated by the constant deluge of spray and waves, is no doubt provided by the thick covering of non-wettable microscopic pile on all parts of the body and dense microtrichiae of the wings. Occasionally adults may be seen actively scampering, mating, and ovipositing during the day, even in bright sunlight but more often on cloudy days, but generally the day is spent resting on the shady side of moist rocks. The Australian species *T. australicus* is diurnal, according to Womersley, appearing by thousands on bright sunny days in summer. The fresh-water Hawaiian species are much more markedly diurnal and are quite active in bright sunlight, but may be found in greatest num-

bers resting, ovipositing, mating, and running about on the shady side of boulders just above the water line or where drenched by spray. These adults are often dislodged by large pelting spray drops or marginal ripples, to be carried downstream on the swift current, but may soon be seen working their way up again by their characteristic erratic racing flight just at the water surface, generally near the stream margin where the current is less swift. There are no records of natural enemies of the marine species, though as indicated by Williams (1939, p. 314) the predaceous dolichopodid fly, *Cymatotopus acrosticalis* Parent which is so abundant on Hawaiian shores, must take its toll of *T. pacificus* and *japonicus*, and the writer has observed *Lispa*, probably *metatarsalis* Thomson, a common anthomyiid predator, stationed on boulders at the beach waiting for passing insects. Williams (1944) notes an anthomyiid fly (*Lispocephala* sp.) and the fire ant (*Solenopsis geminata* [Fabr.]) predaceous on the freshwater species; to these the writer can add the jumping spider (*Hasarius* sp.) attacking *Telmatogeton* adults which venture too far up the sides of boulders from the spray-drenched water line.

The males of all *Telmatogeton* are remarkable in having the genital segments of the abdomen rotated through about 65-90°. In most other Diptera where rotation occurs, it is nearly always a full 180° or complete inversion. Although the torsion is most commonly to the left in *Telmatogeton*, individuals occur with the terminal segments normal or turned to the right. Saunders (1928) in discussing a similar phenomenon in the very closely related *Paraclunio alaskensis* concluded that these variations indicated that twisting did not occur immediately upon emergence as in other Diptera, but was the result of copulation; but Tokunaga observed that in *japonicus* the twisting took place in the "shining" phase of the pupal stage just before eclosion. Copulation takes place on the rocks with the male straddling the female and his abdomen usually to the right, although generally several males, which seem to be more numerous than the females and quite avid, become involved in a tangle during the competition. On the dorsum of the last abdominal segment of the males there is a membranous protrusible "anal tube" the function of which remains obscure, but which Saunders believed would most likely be used in copulation.

Egg.—The eggs of *T. japonicus*, the only marine species for which the egg is known, are stated by Tokunaga to resemble closely those of *Paraclunio alaskensis*. These number 150 to 190 in the newly emerged female and are almost all laid during her 20-hour lifetime, singly in small pits or crevices in the rocks of the habitat. Saunders describes and figures the eggs of *P. alaskensis*, which are ovoid, 0.4 by 0.2 mm. in size; with conspicuous micropyle, chorion smooth, shining; color yellow when deposited, darkening to dull olive green; these are inserted singly in the filamentous

algae of the habitat. Terry described the egg of *T. torrenticola*, a fresh-water species; these were said to be ovoid, 0.2 by 0.3 mm., micropyle conspicuous, chorion shining, color yellow darkening to olivaceous, and without gelatinous covering; deposited on end, micropyle up, in single layers on the rocks or submerged timbers just below the water surface, often in masses of several thousands. Williams figured the eggs of *T. williamsi*, apparently with a gelatinous covering enclosing the "shining dark-tipped eggs" which he stated were "found in clusters slightly under the water or at its edges," and which hatched in about a week in the laboratory.

Larval habitat.—The immature stages of all the marine species seem to prefer a fairly comparable habitat, on the seaward faces of algae-covered rocks between tide-marks and situated so as to be swept free of sand and debris by fairly heavy surf. Each species so far studied has been associated with a definite dominant alga-type. The South African species, *T. sancti-pauli* and *T. minor*, were found by Hesse rather closely associated with the algae *Porphyra capensis* on the Atlantic side of the Cape and *P. vulgaris* on the Indian Ocean side; the larvae of *sancti-pauli* forming their tunnels between the folded fronds of the algae where drenched by the waves only at high tide, and those of *minor* preferring to crawl about freely or in silken tunnels on the bare rock surface in the shade of the algae and at a somewhat lower inter-tidal elevation less subject to drying. Tokunaga found *T. japonicus* colonizing only on *Enteromorpha compressa* *Ulva pertusa*, and *Monostroma* sp. in Japan; the young larvae often crawling about and building their tubes among the algae, but after the second instar confining their nests to the rock surface around the algal-bases, and rarely creeping out of the nest; he states that the food consists of fragments of the dead and living algae from their shelter. Although the larvae of *japonicus* were not discovered in Hawaii, the adults were confined to an area of bay-front boulders marked by a growth of the algae *Ulva* sp. and *Enteromorpha* sp. on the Hilo water-front near a large storm sewer outlet, indicating possibly that this species is adapted to water of low salinity as characterized by the algae. Williams (1944) found *T. pacificus* associated with the sparse growth of *Ectocarpus* at the upper tide belt; the writer has also observed this species on Oahu with the larval cases at the algal-bases and more commonly in the pits and fissures in the bare rock surface; the larvae in all stages were often seen with their heads and anterior fourth of the body protruding from the cases. In Japan Tokunaga found *pacificus* associated with the algae *Endocladia complanata*, *Nemalion pulvinatum*, and *Monostroma* sp. Saunders states that the larvae of *P. alaskensis* in British Columbia may be found in almost any matted growth of filamentous algae, preferably on the vertical sides of rocks, at the higher inter-tidal levels.

For the freshwater species, Terry's description of the habits of the larva of *torrenticola* are supported by those of the writer. The silken larval cases are most often built on the sides of boulders or on the smooth-rock bed of rapids and falls where the water runs swiftest. The larvae seem to fare best when the water is swift enough to sweep the rock bare of algae and diatoms though many cases are found where the algal layer is thin. Larvae have been found at depths of a foot or so in large streams and flumes, but are most numerous at a few inches below the water surface at the edges or in shallows. The larvae are commonly seen in all stages with their heads and anterior segments projecting free of the case, but they by no means rarely retreat within their tubes, probably to rest and molt. Larvae are very seldom seen entirely outside of a tubular retreat, probably forming quick prey if they do venture forth. Dissection of gut contents of *T. williamsi* showed an abundance of diatoms and filamentous green algae, as well as a mass of unrecognizable amorphous material, probably soil, organic matter or partially digested vegetation. The duration of the larval stages is not known for any species, but it is believed to be rather long, possibly several months.

Pupa.—Pupation takes place in a specially thickened portion of the case or tube occupied by the mature larva; in a fold within a frond of alga in the case of *sancti-pauli*, and on or in a pit or crevice in the rock surface in most other species. The pupal period was determined by Tokunaga as about two and a half days for *japonicus*, but Hesse states that in the laboratory the period for *sancti-pauli* was from four to seven days or more. In the marine species emergence of adults takes place at low tide when the pupae are exposed; Tokunaga found that in *japonicus* emergence is usually completed in about thirty minutes. In the fresh-water species pupation occurs in a thickened part of the larval tunnel near the water surface, and on eclosion the pupa wriggles out until the cephalothorax is free, the truncated abdominal disc probably serving well to hold the insect against the swift current. Various functions have been assigned to this remarkable abdominal disc. Terry described it as "sucker-like"; Saunders believed that it "is used as a piston in a tube to force the pupa to the surface when ready to emerge," and in addition to the latter function Tokunaga stated that the disc was used for protection in the open cylindrical nest case, serving to prevent the pupa from being washed away by the waves. It is most likely that the thick cylindrical truncated pupal abdomen with terminal disc of *Telmatogeton* is the shape naturally evolving as a result of exposure to the high pressures set up by the violent motion of the surrounding water, these forces being freely transmitted through the ends of the silken nest case. Then, through the development of strong marginal hooks and spines on the disc this structure was in turn developed into a device for holding the pupa more

tightly in the case and assisting in eclosion. It is interesting to note that in addition to the allied *Telmatogeton* and *Paraclunio*, one other genus—*Thalassomyia*, possesses this modified abdominal disc in the pupa. This character would serve to ally *Thalassomyia* more closely with the clunionines with trilobed tarsi thus leaving *Clunio* more or less isolated.

The seasonal occurrence of *Telmatogeton* is probably more marked in temperate regions. Hesse stated that with *sancti-pauli* "There is reason to believe there is more than one generation per year, but that the winter or colder and more moist part of the year is more favorable." In *japonicus* Tokunaga believed "there may be two generations a year, imagines emerging twice, in the spring and summer seasons." The seasonal fluctuation in numbers also has its parallel in the seasonal variation of size of adults, and is probably due to the drying out and recession of the algal beds during the hot summer weather, depriving larvae of food and shelter. The spring forms of *japonicus* are stated by Tokunaga to be much larger than the summer forms from the same locality; this is also discussed for *Paraclunio alaskensis* by Saunders. Such variation in size renders difficult any attempt to differentiate species by comparing sizes. In the Hawaiian Islands where there are no marked seasons and the ocean temperature is rather constant, no seasonal variation in size or numbers has been noted for either marine or fresh-water species, breeding being continuous. However, adults of *T. fluviatilis* collected in a Manoa Valley, Oahu, stream which had been seriously diminished by drouth were less than half the size of typical examples.

SYSTEMATIC TREATMENT

Genus *Telmatogeton* Schiner.

Group A. *Charadromyia* Terry. (Hawaiian Islands; fresh-water species) Male tarsal claws elaborating from the bifid type found in *japonicus* to a simple condition as in female (figs. 1d; 2c, d, e; 4d, e); antenna with segments 3-6 bare, 7 elongated (figs. 1a, b; 2a; 3a, b); female genital segments bluntly conical; male phallosome conical, simple.

1. *torrenticola* (Terry) Hawaii, Maui, Molokai
2. *hirtus* sp. nov. Kauai
3. *williamsi* sp. nov. Oahu
4. *fluviatilis* sp. nov. Oahu
5. *abnormis* (Terry) Kauai, Oahu

Group B. *japonicus* group. (Pacific coasts; marine)

Male claws bifid, asymmetrical (fig. 5c); antenna with segments 3-6 bare, 7 short (fig. 5a); female genital segments moderately tapering; male phallosome conical, simple.

6. *japonicus* Tokunaga Japan, Hawaiian Is.
7. *australicus* Womersley South Australia

Group C. *simplicipes* group. (Pacific coasts; marine)

Size small, color light; male claws bifid, symmetrical, pectinate arm longer (fig. 5d); antenna with segments 3-6 without hairs (fig. 5b) (sense bristles present in *simplicipes*), last segment short, scarcely tapering; cubital fork of wing much beyond r-m in two species (fig. 5h); female genital segments very long and tapering in two species; male basistyles narrow, dististyles ovoid, prominent rounded lobe ventral to phallosome, which is slender (fig. 5g).

8. *simplicipes* Edwards So. Chile
 9. *pacificus* Tokunaga Japan, Hawaiian Is.
 10. *pusillum* Edwards Marquesas Is.

Group D. *Trissoclunio* Kieffer. (Indian Ocean, So. Africa, So. Chile; marine)

Size moderate to large, color dark brown; male claws bifid, asymmetrical (fig. 7d); mid-trochanters of male with a long process or short knob ventrally; antenna with hairs on segments 3-6, last segment short and tapering (fig. 7a); female genital segments long and tapering, upturned (fig. 7b); male basistyles with dorsal margin setose, phallosome with prominent lateral apophyses (fig. 7c).

11. *sancti-pauli* Schiner So. Africa, St. Paul Is.
 12. *minor* (Kieffer) So. Africa
 13. *trochanteratum* Edwards So. Chile

TABLE I

TIBIAL SPUR FORMULAS,¹ LEG RATIOS,² AND ANTENNAL RATIOS³
 IN VARIOUS SPECIES OF *Telmatogeton*

	Spurs	Leg Ratios			Antennal Ratio
		Front	Mid	Hind	
<i>torrenticola</i>	1:1:2	0.58	0.30	0.50	0.61
<i>hirtus</i>	1:1:1	0.50	0.28	0.50	0.51
<i>williamsi</i>	1:1(2):2	0.57	0.38	0.52	0.56
<i>fluviatilis</i>	1:1:2	0.60	0.43	0.50	0.59
<i>abnormis</i>	1:1:2	0.57	0.42	0.50	0.39
<i>japonicus</i>	1:1:2	0.54	0.40	0.50	0.42
<i>pacificus</i>	1:1:1	0.59	0.50	0.55	0.34
<i>sancti-pauli</i>	1:1:1	0.60	0.37	0.59	—
<i>minor</i>	1:1:2	0.60	0.37	0.50	—

¹ Fore, mid, and hind tibiae respectively.

² Length of basitarsus divided by length of tibia.

³ Length of distal segment divided by combined length of remaining segments of flagellum.

GROUP A

1. *Telmatogeton torrenticola* (Terry).

Charadromyia torrenticola Terry, Proc. Haw. Ent. Soc., 2: 292, 1913 (male, female, immature stages; Maui and Hawaii; habits; figures).

Telmatogeton torrenticola Edwards, Konowia, 7: 236, 1928 (from *Charadromyia*); Williams, Proc. Haw. Ent. Soc., 12: 169, 1944 (Molokai, new locality; habits; figures).

Male.—Length of body, 6 mm.; wing 4.5 mm.; breadth of wing 1.3 mm. General color black, mesonotum, pleura, and postscutellum pruinose; legs, humeral angles of mesonotum, wing bases, halteres and pleura brown to brownish black; wings cloudy brownish black.

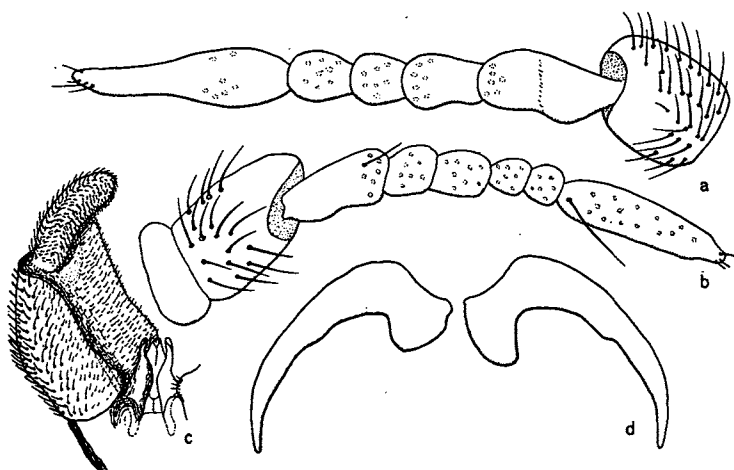


Figure 1. a) antenna, *T. hirtus*; b) same, *T. torrenticola*; c) male genitalia, *T. torrenticola* (right basistyle removed); d) tarsal claws of male, *T. hirtus* (*T. torrenticola* similar).

Antenna (fig. 1b) seven-segmented; basal segment large, subcylindrical, about half again as long as broad, its diameter about twice that of distal segments, with many long black setae on basal two-thirds; second segment about twice as long as broad at tip, appearing crooked due to a constriction at middle, with a long seta on distal portion; segments three to six sub-spherical, without setae; distal segment about four times as long as broad at base, proximal three-fourths subparallel, suddenly constricted apically to a small terminal knob, one or two long setae at base of segment; ratio of lengths of antennal segments beginning proximad, 55:40:20:18:14:65; entire antenna densely pubescent and flagellum with numerous sensory pits. Palpi incompletely two-segmented, the basal portion short, unsclerotized, bare; the distal portion sclerotized, about twice as long as wide, thumb-shaped, and with scattered long black setae. Paraglossae long and prominent,

larger than palpi, setigerous apically. Clypeus darkened and densely clad with numerous long black setae; vertex dark with patches of long black setae just above the eyes.

Lobes of pronotum each with three to five setae. Mesonotum large, strongly and narrowly arched anteriorly and overhanging the head, humeral angles indented; broadening midway and continuing full to wing bases; two short sublateral pre-scutellar furrows; four or five small setae in sub-dorsal rows (these may be absent), four or five long setae in each supra-alar group. Scutellum with about 30 long black setae, the longest of these not as long as length of scutellum; postscutellum long and bare.

Wings appearing opaque, dark brownish-black; radial veins and intervening area to costa darker, several small even darker spots scattered on subcosta; costa thickly beset with small spines, these becoming smaller toward wing tip, about 15-20 small setae on R_1 , 6 on R_1 , and 15 on R_{4+5} ; other veins bare; squama fringed with about 30 long hairs, posterior margin with fringe of fine hairs becoming progressively shorter toward tip where they are almost imperceptible. Crossvein r-m about midway of wing, strong and oblique; R_1 entering costa at about two-fifths the length of R_{4+5} which is slightly curved, meeting costa well before the wing tip, which is rather roundly pointed and closer to tip of M than to R_{4+5} ; M almost straight, very slightly sinuate, ending in wing margin just below wing-tip; fCu at level of base of r-m; Cu₁ gently curved to meet the wing margin at a 40° angle; Cu₂ strongly curved distad to meet the wing margin at right angles. Relative lengths of R_1 , R_1 , R_{4+5} , base of M, and distal section of M, 16:6:15:14:19 respectively.

Legs long; relative lengths of segments from coxa distad, 5:2:14:18:10.4:3.7:1.8:1.8:3.8 on front legs, 5:2:22:19:5.7:2.5:1.5:1.5:3.8 on middle legs, and 6:2:25:22:11:5:1.7:1.6:2.5 on hind legs. Coxae large; trochanters simple; femora and tibiae slender; apical tibial spines single on front and middle legs, two on hind legs, pubescent at base; also a pair of small ventral spines at the tips of each of the proximal four tarsal segments of each leg. Last tarsal segment deeply trilobed, middle lobe extending to tip of claws, the lateral lobes about three-fourths as long; empodium long, pectinately plumose. All claws (fig. 1d) long and sharp; simple, not at all bifid; each claw with an adjacent lanceolate hyaline lamella mesad. Anterior side of coxae, trochanters and all of femora, tibiae and tarsi setigerous, setae of coxae especially dense, long and black.

Abdomen sparsely covered with very fine setae arising from light-colored ocellate spots, those on tergites practically disappearing posterior to fifth segment, while the hairs on the sternites remain quite prominent caudad to the eighth segment. First seven segments with a sublateral pair of narrow diagonal unpigmented lines with the bases cephalo-mesad, rather prominent in alcoholic specimens. Male genitalia (fig. 1c) small, rotated variably to right or left between seventh and eighth segments. Basistyles stout, slightly longer than wide, slightly tapering distad, concave dorso-mesally, with numerous short hairs laterally, fine setae mesad. Dististyles ovoid, flattened, infolded, slightly concave on flexor surface, slightly more than twice as long as broad, bearing dense fine setae, these directed proximad on flexor surface. Phallosome conical, directed dorsad from between bases of basistyles, the hyaline inner lobe with two lateral rounded apical lips, guarded on each side and fused on basal half with two sclerotized clavate plates which are narrowly united basally and joined by a sclerotized bridge to the dorsal articulation of the basistyles and to the proximal ends of the prominent rod-like sclerotized parameres which in turn project distally inside the basistyles. The membranous wrinkled pubescent anal lobe projects dorsally on the eighth tergite anterior to the phallosome.

Female.—Similar to the male in color, vestiture, and general characteristics, slightly larger in size, the wings not reaching the tip of the abdomen, the legs slightly shorter though the proportions of segments remain the same. Tarsal claws as in the male, long and simple. Eighth abdominal segment

narrowed laterally, triangularly tapering from side view, not as long as high; the cerci large and ovoid, located at pointed tip of abdomen at level of pleural margins of abdominal segments; the long slender dorsal valves of ovipositor enclosed by the cerci; the ovoid ventral valves located at tip of eighth sternite just anterior to and the apices enclosed by the cerci; entire genital appendages densely pubescent; eighth sternite with a patch of fine hairs just anterior to bases of ventral valves, rest of eighth segment practically bare.

The larva and pupa of *T. torrenticola* were described by Terry. The larvae are as described in detail below for *T. williamsi* with the following differences: 1) larger, length mature 12-16 mm.; 2) antenna longer, first segment about twice as long as wide; 3) mentum as in *hirtus*, rounding in outline, median tooth blunt, broadly rounding, six progressively smaller teeth on each side; 4) 19-23 hooks on each posterior pseudopod.

The pupa resembles those of the other Hawaiian species described below, with the following important specific details: 1) spiracle located at proximal third of respiratory lobe; 2) preapical abdominal segments with fine shagreening along basal median sclerotized lines on tergites and sternites, on third sternite there is a small triangular brownish patch of heavier shagreening in the center of basal shagreening; there are also small patches of fine slightly yellowish shagreening at the apex of each lateral sclerotized line on second to sixth tergites and third to sixth sternites; 3) terminal abdominal disc with the denticles heavily sclerotized brownish, the central area of the face of the disc with numerous raised fine tubercles, and about 10-13 hairs in submarginal area on ventral side on each side of genital lobes.

Material examined: From the Bishop Museum collection: *Mau*i: 1 female, Nahiku, January, 1908, Terry coll.; 1 female, Haipuaena, C. N. Forbes, coll.; 1 female, Waiheea, September 4, 1919, E. H. Bryan; 1 male, 1 female, Waikapu, June 11, 1920, Caum, coll.; 30 males, females, Iao Valley, January 3, 1915, J. F. Illingworth. From the H.S.P.A. collection: *Hawaii*: 10 males, 8 females, Kau-
mana, April 29, 1920, O. H. Swezey; 6 males, 4 females, Kohala, May 5, 1906, June 19, 1907, F. W. Terry ("In plantation flumes"—also 1 larva, 1 pupal skin); 1 female, Hilo Sugar Co., 1000 ft., July, 1932, F. X. Williams; 4 males, 1 female, Akaka Falls, October 24, 1931, F. X. Williams (wet rocks); *Mau*i: 3 males, 11 females, Nahiku, January 9, 1908, F. W. Terry (also 2 clusters of eggs); *Molokai*: 1 female, Honouliwai, December 1, 1933, F. X. Williams (1000 ft., rushing waters); 3 females, Moalua Stream, 2000 ft., November 29, 1933, F. X. Williams (at waterfall). Wirth collection: *Hawaii*: 100 males, females, Rainbow Falls, Hilo, February 27, March 3, 1946, W. W. Wirth (also numerous larvae and pupae); 30 males, females, Akaka Falls, March 3, 1946, W. W. Wirth; 1 male, Kohala ditch, March 1, 1946, W. W. Wirth.

Telmatogeton torrenticola is the only fresh-water species found on the islands of Hawaii, Maui and Molokai. It is distinctive in the large simple claws of the male, the large size, and reduced hairy vestiture. No unusual habits were noted while collecting adults, larvae, and pupae. This species was particularly abundant at Rainbow Falls, (400 ft. above sea level) about a mile and a half from the mouth of the Wailuku River, and one specimen was collected on the rocks along Hilo Bay about half a mile from the mouth of the river, where it had evidently been swept downstream by the swift current and had drifted along the bay-shore.

2. *Telmatogeton hirtus* sp. nov.

Telmatogeton sp. no. 2, Williams, Proc. Haw. Ent. Soc., 12: 169, 1944 (notes; fig. 47, spiracular lobe of pupa; Kauai).

Male.—Length of body, 8-10 mm.; wing, 7-8 mm.; breadth of wing, 2 mm. General color black, pleura, mesonotum and postscutellum pruinose; legs, antennae, palpi, humeral angles of mesonotum, and scutellum dark brownish black; halteres brown; wing opaque brownish black. The most conspicuous feature of the entire insect is the marked elongation of the body hairs, most of these being as long as two to three times the diameter of the tarsi, and wavy towards the tip, giving the insect a remarkable "fuzzy" appearance.

Antenna (fig. 1a) seven-segmented; basal segment about one-fourth longer than broad, its diameter about twice that of distal segments, covered with many long setae; second segment about twice as long as broad, constricted in middle; segments three to six sub-spherical, without setae (sometimes only three of these segments present, the antenna appearing only six-segmented); distal segment four or five times as long as wide at base, markedly tapering from base to a long narrow tip bearing one or two fine subapical setae. Ratio of lengths of antennal segments, beginning proximad, 55:60:30:22:22:80; entire antenna densely pubescent and with numerous sensory pits. Palpi small and incompletely two-segmented, setigerous, basal segment sub-globular, enlarged, second segment short and oval; clypeus and vertex above eyes with numerous long black setae.

Lobes of pronotum each with fifteen to twenty long black hairs. Mesonotum large, strongly and narrowly arched anteriorly and over-hanging the head, humeral angles strongly indented; broadening widely and continuing full to wing-bases; two short, shallow but broad pre-scutellar furrows; about 6-15 long setae arising from light-colored ocellate spots in each subdorsal row; about 20 scattered hairs from ocellate spots in pre-scutellar patch; and about 20 hairs set close together in a common poorly sclerotized base in a compact supra-alar group. Scutellum with about 50 or more long black fine hairs, these somewhat longer than length of scutellum; postscutellum bare.

Wings appearing opaque dark brownish black; costa thickly set with long fine hairs, these gradually decreasing in length toward wing-tip where they are almost pile-like; base of radius thickly set with long hairs, these sparser and shorter on distal portion of radius, about 10-15 long setae on R_1 , about 5-6 minute setae on R_{4+5} , other veins bare; squamae densely fringed with long wavy black hairs; posterior margin with a fringe of fine hairs becoming shorter toward wing-tip. Cross-vein r-m slightly beyond middle of wing, strong and oblique, R_1 entering costa slightly before half the length of R_{4+5} , which is slightly curved distad, meeting costa well before the wing-tip, which in turn is broadly rounded and situated about midway from the tips of R_{4+5} and M; M rather sinuate, fCu at level of base of r-m, Cu₁ gently curved, Cu₂ short and evenly but strongly curved to meet wing-margin at right

angles. Relative lengths of R, R₁, R₄₊₅, base of m, and distal section of M, 18:8:15:15:20 respectively.

Legs long; relative lengths of segments from coxa distad, 5:2:17:20:10:4:2:1:7:4 on front legs, 5:2:21:19:5.4:2:1.4:1.4:4 on middle legs, and 6:2:24:22:11:6:2:2:4 on hind legs. Coxae large, densely covered anteriorly with long black hairs; trochanters small, simple, only a few long hairs on antero-distal margin, remainder of legs slender and densely hairy, hairs very long and wavy, except shorter on ventral surfaces of segments; apical tibial spines single on all legs, also a pair of small ventral spines at the tips of each of the basal four tarsal segments of each leg. Last tarsal segment deeply trilobed, the lateral lobes about three-fourths as long as the median lobe; empodium long, pectinately plumose. Claws (fig. 1d) nearly as long as basal part of fifth tarsal segment, and twice as long as median lobe, sharp and simple, no trace of bifid condition except for a slight thickening at about proximal third of claw; each claw with a long lanceolate hyaline lamella (pulvillus) arising mesad at base.

Abdomen clothed with fine setae arising from light ocellate spots, these longest on first tergite, becoming shorter on posterior segments and on sternites; the anterior and lateral margins of each tergite and sternite more heavily sclerotized. Male genitalia turned to the right or left variably; basistyles stout, nearly as broad as long, slightly concave dorso-mesally, densely clad with coarse setae on lateral surface, fine setae mesally, disistyles sausage-shaped, slender, about three times as long as broad, scarcely tapering distad with rounded tips, folded mesad and clad with fine setae which are directed proximad on the flexor surface. Phallosome consists of a median dorsally directed hyaline tube with rounded lips guarded on each side and fused on proximal half with two hyaline plates tapering and recurving anteriorly to a sharp point; phallosome plates narrowly united basally and joined laterally to basal dorsal articulation of basistyles by a sclerotized bridge. Anal tube membranous, densely pubescent and wrinkled, opening on eighth dorsum anterior to phallosome.

Female.—Similar to male in size, coloration, and general characteristics. Vestiture of entire body, which in the male is so remarkably characterized by fine long wavy hairs, is in the female more or less as in other species of the genus; while the hairs and setae are quite dense and fine as in the male, the hairs themselves are quite short; those on the legs being about half as long as the breadth of the segment on which borne. The female claws are long, simple and curved as in the male. Eighth abdominal segment reduced, triangular in lateral outline, about half as long as high, and laterally compressed; the small bluntly rounded cerci borne apically on a line with the ventral margin of abdomen and enclosing the valves of the ovipositor; genital segment practically bare of setae, cerci pubescent.

Larva.—Length mature, about 12-15 mm.; head capsule 1.5 mm. long by 0.9 mm. wide. Color olivaceous green, head capsule sclerotized dark amber-brown, black along epicranial suture, cervical border, and distal half of mentum and mandibles; hooks of pseudopods dark brown.

Head barrel-shaped, slightly flattened dorso-ventrally, region of clypeolabrum narrower and produced ventro-cephalad nose-like. Integument of head with pebble-grained sculpturing and irregularly wrinkled sclerotizations. Frons nearly twice as long as wide, widest at anterior third, anterior margin truncated by the transverse fronto-clypeal suture which is about three-fourths as long as greatest width of frons; frons bluntly pointed caudad at the junction of the arms of the epicranial suture. The post-clypeus is evident as a distinct small quadrate sclerite immediately cephalad of frons, slightly wider than long and a little more than half as wide as fronto-clypeal suture; the small transverse elliptical pre-clypeus is separate from and just anterior to the post-clypeus. The lateral and cephalic margins of the clypeolabrum are roundly continued ventrally forming an overhanging "upper lip"

with the margins strongly sclerotized. The small antennae are borne laterally at level of fronto-clypeal suture, the large proximal segment is about twice as long as broad and about half again as long as the remaining distal segments, second segment peg-like, about a third as broad and a third as long as proximal segment, bearing two minute distal segments and several small spines; a biramous membranous Lauterborn's organ adjacent to and as long as distal three segments also borne at end of proximal segment. The dorsum of the head bears rather heavy amber hairs as follows: a pair just in front of antero-lateral corners of frons; a pair on the frons just within the antero-lateral corners; a pair on lateral margin of frons about a third-way back; a pair on the vertex just laterad of the arms of the epicranial suture at level of posterior third of frons; and several smaller hairs on each side scattered below and behind the antennae. A small irregular eyespot on each side of head just behind antennae.

Labrum folded downwards and emarginate; the cephalic margin bearing a variety of spines, pegs, and setae mesally, and several combs of long flattened hairs at sides; the paired premandibles borne laterad with the flattened 3-toothed apices directed mesad. The large heavily sclerotized mandibles bear five large blunt black teeth on distal third which is blackened, proximad of these on mesal margin is a small brown tooth and a stout hyaline distally directed spine reaching to the ante-penultimate tooth; there are two long setae on ventral surface of mandible near base and the dorsal surface bears a compact brush of long hairs. The maxillae are flattened, rhomboid in outline, with a basal elongate sclerite bearing one or two long setae and a rounded distal sclerite bearing the short unsegmented truncated palpus. The anterior margin of maxilla is fringed with a beard of flattened setae progressively longer from base of maxilla; the distal margin around palpus bears a number of pegs and spines, and extreme posterior tip bears another beard of long flattened hairs. The mentum is nearly circular in outline except for base, the median tooth irregularly flattened in outline, quite broad, on each side are six sharp progressively smaller and shorter teeth counting the minute basal tooth; distal half of mentum blackened. Hypopharynx consists of a small median lobe heavily bearded with long flattened hairs supported by two slender sclerotized arms in a V-shaped bridge.

Prothoracic pseudopod bilobed at tip, each lobe crowned with many brown hooks ranging in size from small recurved hooklets or spines well up on posterior side to long slender slightly curved hooks at apex on anterior side. Thoracic and abdominal segments with setae more numerous and longer than in other species in genus; thoracic segments each with about six long black single or double setae on each side, abdominal segments I-VIII each with four scattered black setae on each side. Ninth segment rounded dorsally, indistinctly segmented into a ventro-posterior portion bearing the anus between a pair of stout pseudopods; these each with a mesally interrupted crown of 20-25 strongly curved stout black hooks at apex; adjacent to the anus are three sausage-shaped gills, the posterior or median unpaired gill longer, about three times as long as broad and nearly as long as a pseudopod, the pair of laterally projecting gills are about half as long and are directed to the hook-free portion of the pseudopods; the dorsal portion of ninth segment bears three sub-lateral pairs of fine black setae and a pair of quite long stout double or triple posterior hairs; each pseudopod with three or four black setae in a horizontal row about halfway on lateral side.

Pupa.—Length, about 9 mm.; color olivaceous green, darkening as the developing imago matures; exuvium sclerotized dark amber brown in region of cephalothorax and terminal abdominal disc, abdominal segments transparent except for narrow U-shaped sclerotizations along basal and lateral margins of tergites and sternites. A long hair arises just mesad of base of each antenna, a long hair on each humeral corner, two hairs just mesad of

base of each respiratory organ, a pair just anterior to wing bases and a pair of widely separated pre-scutellar hairs. Respiratory organ horn-shaped, as in genus, spiracle minute, opening dorsally on proximal third of lobe.

Abdominal integument shagreened, these markings much more pronounced and amber colored along anterior sclerotized lines of tergites; first tergite with a large central brown shagreened patch, tergites of II and III with brown shagreening covering most of segment; tergites and sternites of preapical segments each with about ten scattered black setae, these rather long in the male pupa, but reduced in the female. Margin of both dorsal and posterior sclerites of terminal abdominal disc with very coarse uneven brown heavily sclerotized denticles, on posterior sclerite these denticles bear a fringe of numerous fine amber colored hairs except at extreme posterior apex. Face of dorsal sclerite of disc with four long black hairs near margin, surface heavily and irregularly corrugated; face of posterior sclerite bears two pairs of long black hairs in a submedian trapezoid, surface with pebble-grained thickenings, especially along margins, two submedian brown longitudinal lines are distinctive. Trunk of eighth segment anterior to disc not sclerotized but bears long black hairs as follows: a sublateral pair and a pair at extreme lateral extremity of dorsal sclerite of disc, two lateral pairs just ventral to ends of transverse suture of disc, three sublateral pairs on each side of and anterior to genital lobes, three to five pairs of sublateral hairs where trunk of eighth segment joins the disc, and eight to ten hairs scattered on each side along ventral margin of disc.

Holotype, male, *allotype*, female, Wainiha stream, Kauai, September 8, 1946, W. W. Wirth; *paratypes*: 3 males, same data as types; 1 male, 3 females, Kokee stream at falls into Waimea canyon, Kauai, September 6, 1946, W. W. Wirth; 5 males, 4 females, Kokee, Kauai, Kauaikinana stream, June 9, 1919, H. T. Osborn. *Other material examined*: From Bishop Museum collection: 1 battered torso, Kauai, 4000 ft., April 23, 1919, J. A. Kusche. From H.S.P.A. collection: 1 pupal exuvium, Halemanu, Kauai, June 10, 1919, H. T. Osborn. Wirth collection: many larvae and pupae, Wainiha stream, Kauai, September 8, 1946, W. W. Wirth (on boulders in rapids); many larval, pupal skins, Kokee stream, Kauai, September 6, 1946, W. W. Wirth (at falls into Waimea canyon).

Telmatogeton hirtus has been taken only on the island of Kauai, where it is evidently widespread in the numerous rapid mountain streams draining the Alakai Swamp, a very wet region at about 4000 ft. elevation with as much as 600 inches of rainfall annually. This species was found together with *T. abnormis* (Terry) at Kokee stream, this being the only instance in which the range of two fresh-water species has been found to overlap; the two species are evidently not immediately related and are readily separated in all stages. The habits of *hirtus* were not observed to be different from those of other fresh-water species in any respect.

T. hirtus is readily distinguished from other species by its large size (largest in the genus), the remarkably developed hairy vestiture, especially in the male, the simple tarsal claws of the male, the development of setae on the larvae and pupae, the anal gills in the larva (also present in larvae of *abnormis* from Kauai), and the pair of prominent longitudinal lines on the abdominal disc of the pupa.

3. *Telmatogeton williamsi* sp. nov.

Telmatogeton sp. no. 1 (in part), Williams, Proc. Haw. Ent. Soc., 12: 168, 1944 (biological notes, Waianae, Oahu; figs. 44-46, egg and pupa).

Male.—Length of body, 3-5 mm.; wing, 3 mm.; breadth of wing, 1.0 mm. General color blackish, pleura, mesonotum, and postscutellum pruinose; legs, antennae, palpi, humeral angles of mesonotum, and genitalia dark brownish black; wing dark cloudy gray; halteres light gray.

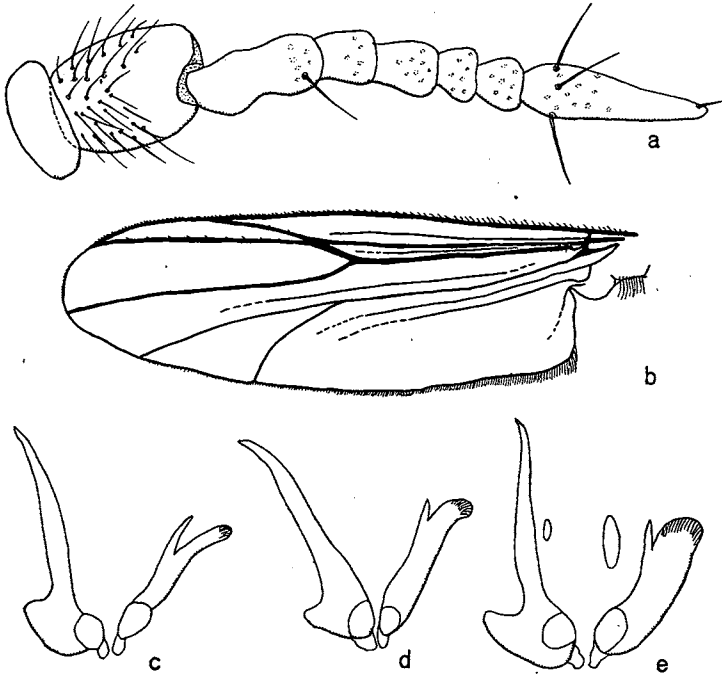


Figure 2. *T. williamsi*. a) antenna; b) left wing; c) claws of front tarsus of male; d) same, mid tarsus; e) same, hind tarsus.

Antenna (fig. 2a) 7-segmented; basal segment large, sub-cylindrical, slightly longer than broad, its diameter about twice that of distal segments, with many long setae; second segment about twice as long as broad at tip, slightly crooked and constricted at middle, bearing a few long setae on distal portion; segments three to six sub-spherical, without setae; distal segment about four times as long as broad at base, strongly but regularly tapering to a finely pointed tip, and bearing two to three long setae at base; ratio of lengths of antennal segments, beginning proximad, 45:40:16:19:12:12:55; entire antenna densely pubescent, segments of flagellum with numerous sensory pits. Palpi one-, sometimes two-segmented, the short bulbous basal segment only occasionally present; the second segment variable in form, but generally ovate, not quite twice as long as broad, with numerous setae.

Paraglossae small, round, setigerous. Clypeus and vertex darkened and bearing numerous strong black setae.

Lobes of pronotum with a few black setae. Mesonotum large, strongly arched anteriorly, extending part way over head; almost bare, the setae small, arising from light-colored ocellate spots, and restricted to a few (6) in each subdorsal row and a small supra-alar patch (6). Pleura bare, grayish brown pruinose. Scutellum with 40-50 black setae, these about as long as half the length of scutellum, postscutellum bare.

Wings with four or five small more darkly infuscated spots on subcosta; costa with numerous short spines throughout its length, these becoming shorter toward apex of wing; base of R with two long hairs, one or two small setae on R_1 , R_{4+5} with about six small setae, other veins bare; squama fringed with about 15-20 long hairs; fringe of fine hairs on posterior wing margin growing progressively shorter distally until almost imperceptible at tip of Cu_1 . End of stem of radius somewhat indefinite, cross-vein r-m strong and oblique, R_1 entering costa at about one-half the length of R_{4+5} , which is slightly curved toward tip and enters costa slightly before the wing-tip; M almost straight, very slightly sinuous; Cu_1 straight except gently recurved apically to meet the wing margin at a 40° angle; Cu_2 straight on basal half, apical half curved to meet the wing margin at right angles; fCu slightly beyond base of r-m. Relative lengths of R, R_1 , R_{4+5} , base of M, and distal section of M, 11:5:12:9:15 respectively.

Legs long; relative lengths of segments from coxa distad, 4:2:14:13:7.4:3:1.5:1.3:2.6 on front legs, 4:2:19:13:5:2:1.3:1.2:2.3 on middle legs, and 4:2:18:13.5:7:4.2:1.5:1.4:2.3 on hind legs. Coxae large; trochanters simple; apical tibial spines one on front legs, one or two on middle legs, and two on hind legs. Last tarsal segment deeply trilobed, the median lobe extending to apex of claws, lateral lobes three-fourths as long; empodium large, pectinately plumose. Tarsal claws (figs. 2c, d, e) unevenly bifid, the lateral tooth being pectinate at tip; on the inner (anterior) claws the lateral tooth is reduced to a small basal projection, while on the outer (posterior) claws the inner tooth is a fine spur arising well toward the tip of the pectinate tooth. Each claw with an adjacent membranous lanceolate lamella and a prominent seta arising near base. Anterior side of coxae and trochanters and all of femora, tibiae and tarsi setigerous.

Abdomen sparsely covered with very fine hairs arising from light-colored ocellate spots. Male genitalia variably rotated; basistyles stout, strongly setigerous ventro-laterally and with fine setae on dorso-mesal surface, with a small dark finely-setigerous lobe on dorso-mesal side near base; disistyles oval, flattened, concave ventrally, folded mesad, with fine setae, these directed proximad on flexor surface. Phallosome conical, inner hyaline lobe dorsally directed with two rounded lateral lips at apex, closely guarded by two lateral apophyses which are fused with inner lobe on proximal two-thirds. Anal tube prominent, membranous and wrinkled, pubescent, on eighth dorsum anterior to phallosome.

Female.—Similar to the male with the following differences: Generally slightly larger; length 4-6 mm.; wing 3-4 mm., broader than in male, not reaching tip of abdomen, especially in gravid specimens. All tarsal claws long, pointed, simple, not bifid. Eighth abdominal segment markedly tapering, triangular in outline, laterally compressed, bare except for a few very fine sparse setae at apex of sternite; ventral valves of ovipositor short, oval, separately placed mesally; dorsal valves nearly as long as cerci within which they closely fit; ovipositor and cerci finely pubescent; a small patch of long setae arise from sclerotized base of ventral valves.

Larva.—Length mature, about 10 mm., head capsule 1.1 mm. long by 0.6 mm. wide. Color olivaceous green, light in younger instars becoming quite dark in mature specimens, head capsule amber to dark brown, especially darkened along epicranial suture; mandibular teeth, mentum, cervical border of head capsule, and hooks of pseudopods black.

Head oval, slightly tapering to anterior, sub-cylindrical in cross-section. Frons about twice as long as wide, widest in middle, curved to a point caudad at junction of arms of epicranial suture; curving anteriorly to base of clypeus which it touches in a transverse suture about half as long as greatest width of frons, two pairs of small hairs borne on lateral borders of frons, one near anterior corner, and the second about one-third of the way back; four small hairs on each side of head, one adjacent to anterior frontal hair near epicranial suture, second near suture, but posterior to first by about half the distance to the sutural fork, a third about the same distance ventrad of the second, and the fourth just ventral to the eyespot. A long hair borne on a large tubercle just laterad of each end of fronto-clypeal suture. Antennae

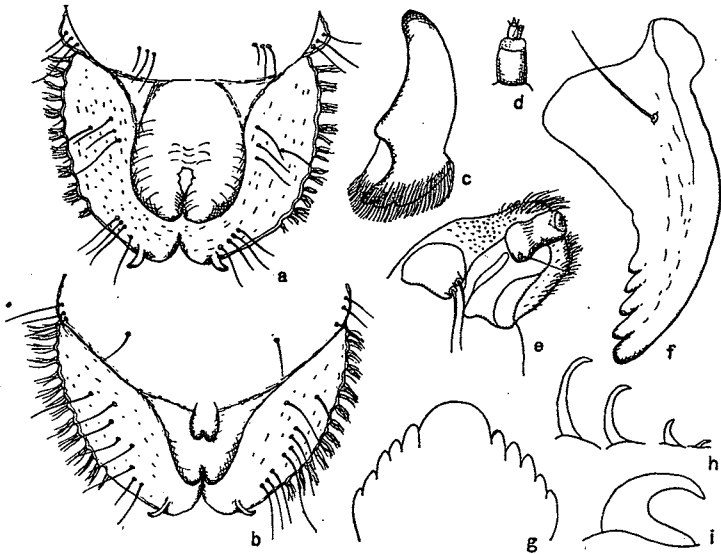


Figure 3. *T. williamsi*, larval and pupal details. a) posterior portion of terminal abdominal disc of male pupa, ventral view; b) same, female pupa; c) premandible of larva; d) antenna of larva; e) maxilla of larva; f) mandible of larva; g) mentum of larva; h) hooks of anterior pseudopod of larva; i) hook of posterior pseudopod of larva.

(fig. 3d) borne laterally at level of fronto-clypeal suture, small and four-segmented; stout basal segment slightly longer than broad bearing a peg-like second and two minute distal segments and a Lauterborn's organ adjacent to and as long as these. A small eyespot located laterally just behind base of mandibles. Post-clypeus small, transverse, about half again as wide as long; pre-clypeus minute and semicircular. Labrum rounding anteriorly, curved dorsally with minute papillae, four hairs widely spaced in a square, anterior margin with a row of ventrally directed spines between two lateral brush-like tufts of hairs; arising posteriorly to these, a pair of appendages (fig. 3c) (premandibles) elongate basally, bearing apically a flattened hairy spatulate outer leaf and a bare flattened inner arm with three flat rounded teeth.

Mandibles (fig. 3f) large, heavily sclerotized, with five large blunt teeth on apical third, two long lateral setae ventrally, and a brustia of long hairs dorsally near base. Maxillae (fig. 3e) rounded, short, bearing several dense

patches of hairs and setae laterally and apically; with a small basal sclerite bearing two long setae, and a principle sclerite bearing a small unsegmented spindle-shaped palp with a hair at base and a number of blunt thick setae at the center of the truncated apex. Mentum (fig. 3g) triangular in outline, with a large rounded median tooth and five small blunt lateral teeth on each side. Hypopharynx consists of a small transverse lobe thickly covered with long hairs, setae and patches of blunt spines borne anteriorly on a sclerotized V-shaped bridge.

Prothoracic pseudopod shallowly bilobed at tip, each lobe bearing a crown of many black hooks (fig. 3h) increasing in size from short curved spines at base to long slender curved hooks at apex. A few fine single or double hairs laterally on each thoracic and abdominal segment. Ninth segment rounded dorsally, indistinctly segmented into a ventro-posterior portion bearing the anus between a pair of short pseudopods, these each with a posteriorly interrupted crown of about 18 strongly curved stout hooks (fig. 3i) of varying sizes at apex; dorsal portion of ninth segment bears a laterally spaced caudal pair of prominent double hairs; no trace of anal gills.

Pupa.—Length, about 6 mm., stout. Anterior margin of cephalic lobe broadly rounded, not bilobed; a long hair arises just mesad of the base of each antenna. Mesothorax arched antero-dorsally, a prominent forward projecting horn-shaped respiratory organ arises from each humeral corner, spiracle at basal third of lobe; three long and one short hairs on mesonotum mesad of each respiratory organ; one long mesonotal hair just anterior to each wing-base, and a pair of widely-separated pre-scutellar hairs; entire mesonotum transversely corrugated. Preapical abdominal segments with narrow delicately shagreened areas bordering the U-shaped sclerotized lines on tergites and sternites; about four minute bristles on each side of each tergite. Dorsal sclerite of terminal abdominal disc with four long black hairs near margin, ventro-posterior sclerite with four long dark hairs placed in a submedian trapezoid. The trunk of eighth segment anterior to the disc is not sclerotized, but bears long black hairs as follows: (figs. 3a, b) a dorso-lateral pair, a line of three hairs grouped near ends of transverse suture of disc, an irregular submarginal row of 8-10 hairs near edge of ventro-posterior section of disc, and a ventro-lateral pair (in female; 3 pairs in male) near base of eighth segment.

Holotype, male, *allotype*, female, Waianae, Oahu, May 2, 1946, W. W. Wirth; *paratypes*: 49 males, 24 females, same data as the types; 27 males, 5 females, Waianae, Oahu, January 23, 1946. *Other material examined*: hundreds of males, females, larvae, pupae, eggs, same data as the types.

All the above specimens were taken from a rock-lined ditch located at about 250 feet elevation about three miles inland from Waianae village. This ditch received swift-flowing water from high up on Mt. Kaala (el. 4000 ft.) which was led downward through a tunnel and discharged through a hydro-electric power-house. The ditch supplied much of Waianae Plantation with water for sugar cane irrigation, hence was kept constantly running. A large number of insects, originally inhabiting the swift mountain streams, have taken up residence in this ditch and similar ditches and flumes supplying the cane fields; such insects include in addition to *Telmatogeton*, *Scatella hawaiiensis* Grimshaw, *S. warreni* Cresson, *S. bryani* Cresson, *S. oahuensis* Williams, *Procanace nigroviridis* Cresson (*Ephydriidae*); *Dasyhelea hawaiiensis* Macfie

(Heleidae); *Tanytarsus lacteiclavus* Grimshaw (Tendipedidae); and *Lispocephala fusca* Malloch (Anthomyiidae).

T. williamsi is quite similar to the other fresh-water species; the male tarsal claws and the shape of the last antennal segment are most distinctive. Great pleasure is taken in dedicating this species to Dr. F. X. Williams, who has contributed so much to the study of aquatic insects in Hawaii.

4. *Telmatogeton fluviatilis* sp. nov.

Charadromyia torrenticola Illingworth, Proc. Haw. Ent. Soc. 7: 408, 1931 (in Waiahole ditch).

Telmatogeton sp. no. 1 (in part), Williams, Proc. Haw. Ent. Soc. 12: 168, 1944 (biological notes; Koolau Mts., Oahu).

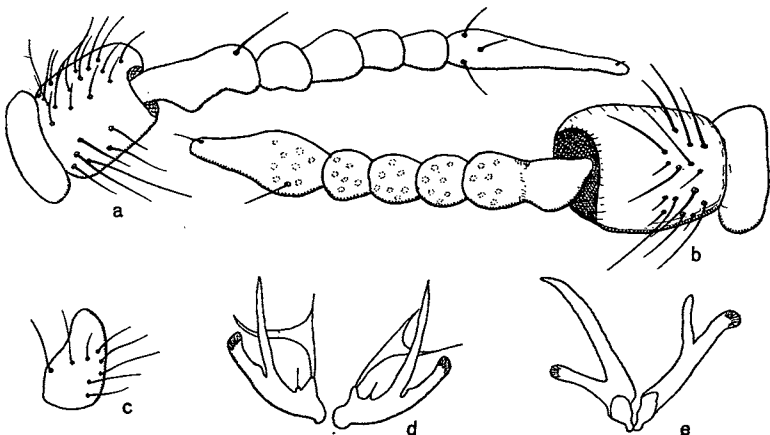


Figure 4. a) antenna, *T. fluviatilis*; b) same, *T. abnormis*; c) palpus, *T. fluviatilis*; d) male tarsal claws of *T. fluviatilis*; e) male tarsal claws, *T. abnormis*.

Male and female.—Very closely allied to *T. williamsi*, which it closely resembles in size, coloration, and general characteristics, but differs distinctly as follows: Terminal segment of antenna (fig. 4a) proportionately longer and much more narrowly tapering at tip; ratio of antennal segments beginning proximad, 40:40:17:20:15:15:62. Claws of all male tarsi (fig. 4d) alike, deeply bifid into a long sharp inner arm and a slender pectinate outer arm about two-thirds as long as the inner; female claws long and simple as usual in genus. Ratio of lengths of segments of leg, from coxa distad, 3.3:1.6:12:11:6.6:2.5:1.3:1.2:2.4 on front legs, 3.1:1.5:17:12:5.2:2.1:1:2 on middle legs, and 3.2:1.5:17:14:7:3.5:1.4:1.2:2.1 on hind legs. Tibial spines 1:1:2. Fewer bristles on scutellum (20-40), these longer, the longest about as long as length of scutellum. Hairs on abdominal tergites longer, especially on the anterior segments. Wings slenderer than in *williamsi*, the fork of Cu occurs slightly proximad of r-m rather than slightly beyond; the setae are longer and more numerous on the radial veins, there being about 20 on R and R_1 , and 5 or 6 on R_{4+5} . Wing length 2.5-3.5 mm.; breadth 0.8-1.0 mm.; body length 3.5-5 mm.

Larva.—Length about 10 mm. As in *williamsi*; proximal antennal segment longer, being fully twice as long as wide; mandibles 5-toothed; mentum 11- or 13-toothed counting a minute lateral tooth, rather rounded distally with a broad rounded median tooth; 20-30 hooks on posterior pseudopods, no trace of anal gills.

Pupa.—Length, about 6 mm. Very similar to *williamsi*; margin of cephalic lobe broadly rounded; respiratory organs as in *williamsi*, preapical abdominal segments minutely shagreened, these markings more prominent along basal transverse sclerotized lines and at tips of lateral lines on each tergite and sternite; at base of third sternite there is a prominent brown patch consisting of round tubercles with pitted apices, probably the most diagnostic marking of the species in the pupa; terminal disc as in *williamsi*, except with the face quite smooth, the marginal denticles less prominent and the tufts of marginal hairs slightly sparser.

Holotype, male, *allotype*, female, Kipapa, Oahu, April 9, 1946, W. W. Wirth (Waiahole ditch); *paratypes*: 50 males, 35 females, same data as the types; 17 males, 9 females, Kipapa, Oahu, February 8, 1946, W. W. Wirth (Waiahole ditch); 17 males, females, Manoa Valley, Oahu, April 10, 1946, W. W. Wirth (at falls). *Other material examined*: From the Bishop Museum collection: 4 males, 4 females, Waiahole ditch, Waipio, Oahu, April 26, 1936, Kiyoshi Ito (PPCA coll.); 6 males, 1 female, Waiahole ditch, Oahu, March, 1915, J. F. Illingworth. From the H.S.P.A. Exp. Sta. collection: 2 males, 1 female, Lulumahu stream, Oahu, April 11, 1937, F. X. Williams; 2 males, Waiahole, Oahu, August 11, 1926, F. X. Williams, 1 female, Manoa, Oahu, November 14, 1929, O. H. Swezey (Aihualama Falls). Wirth collection: 2 males, Punaluu Valley, Oahu, May 14, 1946, W. W. Wirth (concrete ditch from water tunnel).

T. fluvialilis has so far been found only in the streams and ditches from the Koolau mountains, Oahu, as far northwest as Punaluu Valley on the windward side; in the adjacent moist Kulanui Valley its place is taken by *abnormis*, previously known only from Kauai. The paratypes taken from Manoa Valley were quite small compared to Kipapa specimens; this was probably due to unfavorable breeding conditions resulting from the reduction of the stream by extended dry weather; they agreed in all other details with the Kipapa types. The most distinctive characters are the shape of the male tarsal claws, the long narrow last antennal segment, and the prominent brown patch on the third sternite and the smooth face of the terminal disc of the pupa.

5. *Telmatogeton abnormis* (Terry).

Charadromyia abnormis Terry, Proc. Haw. Ent. Soc., 2: 295, 1913 (Kilauea, Kauai; male and female).

Telmatogeton abnorme Edwards, Konowia, 7: 236, 1928 (from *Charadromyia*).

Telmatogeton abnormis Williams, Proc. Haw. Ent. Soc., 12: 168, 1944 (fresh-water, Kauai).

Male.—Length of body, 4.5-5.0 mm.; wing, 3.0 mm.; breadth of wing, 1.0 mm. General color blackish; pleura, mesonotum, and postscutellum pruinose; humeral angles of mesonotum, pleura, wing roots, and scutellum brownish, wing dark cloudy grayish-brown.

Antenna 6- or 7-segmented exclusive of the ring-like antennaria (fig. 4b); basal segment large, subcylindrical, slightly longer than broad, its diameter about twice that of distal segments, with many long setae from proximal portion; second segment twice as long as broad; rather crooked, and constricted in middle (as in most other species) appearing almost as two separate subspherical segments, without setae; segments III to V (and VI when present) subspherical, without setae; distal segment about two and a half times as long as broad at base, gradually tapering on distal two-thirds to a long nipple-like tip, with a fine seta near base, apex of segment I, all of II to V (VI), and base of VII with numerous sensory pits; ratio of lengths of antennal segments, beginning proximad, 48:34:15:15:15:(15):35. Palpi indistinctly two-segmented, thumb-shaped, about three times as long as broad, 6-8 setae scattered on distal portion. Paraglossae small, oval, about twice as long as broad, with scattered setae. Clypeus with numerous fine setae, vertex bare except for a small patch of about 10 moderate setae above and behind each eye.

Lobes of pronotum with 5-6 small setae. Mesonotum large and full, strongly arched anteriorly, flattened between wing-bases; almost bare, the setae reduced to 2-5 in each subdorsal row and 5-6 in a small supra-alar patch, setae all arise from light-colored ocellate spots. Scutellum convex, with about 30 black setae, the longest of these about as long as length of scutellum, postscutellum prominent, bare.

Wings with anterior veins heavy and brownish-infuscated; costa with very fine sharp scattered spines its entire length, these particularly sparse at base of costa; radius with a few setae, 2-3 on R_1 , 4-5 on R_2 , and 1 or 2 on R_{4+5} ; other veins bare; squama fringed with about 30 very fine hairs; posterior wing margin fringed with fine hairs, these decreasing in length distad until barely perceptible at wing tip. R_1 enters costa at about three-fourths way of wing; R_{4+5} nearly straight, ending in costa just before wing tip; M slightly sinuous, ending in wing margin just below wing tip, Cu_1 gently curved, Cu_2 curved to meet wing margin at about 85-90°; base of r-m slightly proximad of middle of wing, fCu at level of base of r-m. Relative lengths of R , R_1 , R_{4+5} , base of M, and distal section of M, 10:5:11:9:13 respectively.

Legs long; relative lengths of segments from coxa distad, 3:1.5:11:11:6.3:2.5:1.1:1:2 on front legs, 3:1.5:15:12:5:2:1.2:1.1:2 on middle legs, and 3:1.5:16:14:7:4:1.2:1.1:2 on hind legs. Coxae large, trochanters simple, front femora clavate basally, other segments of legs slender; apical tibial spines one on front and middle legs, two on hind legs. Last tarsal segment deeply trilobed, lateral lobes nearly half as long as median lobe which is about half as long as portion of segment proximad of base of claws. Tarsal claws (fig. 4e) unevenly bifid, with a sharp inner arm and a pectinate outer arm; on the anterior claws of all legs the sharp inner arm arises about halfway on the side of the pectinate arm, the distal portions of the two being subequal in length; on the posterior claws the pectinate arm arises near the base of the inner arm and is only about half as long as the latter (these observations, made from two specimens carefully mounted on slides for high-power magnification, differ slightly from Terry's figures of the types—his types were also re-examined and agree with the above description). Each claw with a hyaline lanceolate lamella arising from base: a long spine arises from a prominent tubercle between base of claws and lateral lobe on each side; empodium large, pectinately plumose. Anterior and lateral surfaces of coxae with large setae on distal portion; trochanters with dense fine setae ventrally, legs sparsely clad with short fine hairs, the longest of these never longer than diameter of segment on which borne.

Abdomen with very sparse setae arising from light-colored ocellate integumental spots, most highly developed on anterior three tergites and all sternites, posterior tergites nearly bare. Male genitalia rotated variably to right or left. Basistyles stout, nearly as broad as long, tapering distally, concave dorso-mesally, with sparse short hairs laterally and fine setae mesally; dististyles flattened, ovoid, about twice as long as broad, folded mesad, and covered with fine setae which are directed proximad on the flexor surface. Phallosome directed dorsad from between bases of basistyles, consisting of a conical hyaline median cylinder with two rounded lateral distal lips, flanked by and fused on basal half with two hyaline sclerotized plates tapering and recurving anteriorly to a sharp point; phallosome connected at base dorsally with a pair of sclerotic plates forming a bridge with the dorso-mesal articulation of the basistyles, at point of connection a heavily sclerotized plate-like paramere extends well out into the interior of basistyle. A membranous wrinkled pubescent anal tube projects dorsally just anterior to base of phallosome.

Female.—Similar to male in size, coloration, vestiture, and general characteristics. Tarsal claws long and simple, not bifid. Eighth abdominal segment reduced, laterally compressed, and triangular in outline from side, about as long as high, the small blunt-tipped cerci borne apically on a line with the ventral margin of the sternites, and enclosing the dorsal valves of the ovipositor. The ventral valves open ventrad between the bases of the cerci; cerci and valves densely pubescent, eighth sternite with fine hairs especially ventrad, eighth tergite practically bare.

Larva.—Length mature, about 10-12 mm., head capsule 1.2 mm. long, 0.8 mm. wide. Color olivaceous green, head capsule sclerotized dark amber brown, black along cervical border, epicranial suture, and distal half of mentum and mandibles; hooks of pseudopods dark brown.

Head barrel-shaped, slightly flattened dorso-ventrally, shape seen from above oval, slightly tapering cephalad, region of clypeo-labrum narrowed bluntly snout-like and somewhat downcurved; integument with pebble-grained sclerotized thickenings. Frons narrowly shield-shaped, about two-thirds as broad as long, truncated anteriorly by fronto-clypeal suture which is over half as long as greatest width of frons, frons widest at about middle, tapering roundly caudad to a blunt point at junction of arms of epicranial suture. Post-clypeus distinct as a prominent transverse sclerite immediately anterior to frons; width about two-thirds the length of fronto-clypeal suture, about half again as wide as long; pre-clypeus a minute round median sclerite just anterior to post-clypeus. The lateral and cephalic margins of the clypeo-labrum are arched and continued ventrally in a prominent overhanging upper lip, the margins of which are strongly sclerotized, surface of this area with prominent peg-like integumental thickenings. Antennae borne laterally at level of fronto-clypeal suture, four-segmented; the basal segment about twice as long as broad, twice as broad as distal segments and about one and a half times as long as remaining distal segments together; second segment peg-like, slightly longer than broad, bearing the two minute distal segments and several minute spines distally, the basal segment also bears apically a membranous biramous Lauterborn's organ as long as and adjacent to combined distal segments. A pair of small irregular eyespots is situated on side of head behind antennae. Dorsally the head bears rather long hyaline setae as follows: two sublateral pairs just in front of preclypeus on each side; a pair from prominent tubercles just anterior to ends of fronto-clypeal suture; a pair in anterior corners of frons, a pair on lateral margins of frons about one-third way back; a pair just laterad of frons just caudad of widest portion; a pair on side of head just below antennae, and another pair at same level just below the eyespots.

Labrum folded downwards and emarginate, the cephalic margin bearing a variety of curved hooks, spines, pegs, and setae mesally and several tufts or combs of long flattened hairs at sides; the paired premandibles are borne

laterally on the ventral side, their flattened tri-dented apices directed mesad. The large heavily sclerotized mandibles bear five blunt blackened teeth on distal third, a stout hyaline appressed distally directed spine arises just proximad of these; a compact brush of fine hairs arises near base on dorsal surface, and ventral side bears two long setae. Maxillae flattened, subquadrate in outline, with a large dorso-proximal sclerite bearing two stout setae and a second ventral sclerite bearing the short barrel-shaped unsegmented palpus on anterior margin; a hyaline membrane extending from the dorsal sclerite to under the palpus bears a beard of stout flattened spines, while a rounded distal membranous lobe from the ventral sclerite gives rise to a variety of pegs and spines and a distal beard of slender flattened hairs. Mentum arched triangular in outline, the median tooth broad with blunt angularly-pointed apex, six sharp progressively smaller and shorter lateral teeth counting a minute basal tooth on each side. Hypopharynx consists of a membranous lobe bearing a dense beard of long flattened hairs supported by two long slender sclerotized arms in a V-shaped bridge; near the apex of the V these arms are joined by a transverse sclerotized arm, a membrane between the basal arms of the bridge bears an even vestiture of fine flattened setae.

Prothoracic pseudopod shallowly bilobed, each lobe crowned with many brown hooks ranging from long slender slightly curved hooks on cephalic margin at apex to minute retrorse spines halfway up on caudal side of pseudopod. Thoracic segments with 6-10 pairs of lateral setae of varying sizes, abdominal segments I-VIII each with 2-3 pairs of small lateral setae. Ninth segment rounded dorso-posteriorly, indistinctly segmented into a ventro-posterior portion bearing the anus between a pair of stout pseudopods, these each with a mesally interrupted crown of about 17 stout curved black hooks at apex; surrounding the anus are an unpaired posterior and a pair of lateral blunt ovoid gills not quite as long as pseudopods. Dorsal portion of ninth segment bears a pair of prominent double long black hairs on posterior extremity and a few scattered minute setae; each pseudopod bears two or three long hairs about halfway on lateral side.

Pupa.—Length, about 6 mm. Integument of cephalothorax sclerotized amber-brown, with pebble-grained thickenings and irregular transverse wrinkles. Thoracic respiratory organs of usual shape, spiracle small, opening dorsally about midway of lobe. A pair of large amber sublateral setae on dorsum of cephalic lobe, a pair just mesad of bases of respiratory organs, two submedian pairs about halfway between base of respiratory organ and midline, and a submedian prescutellar pair. Integument of abdominal tergites with rather coarse shagreening throughout, a brownish patch on seventh tergite just anterior to terminal disc; only a few scattered minute hairs on tergites and sternites. Terminal abdominal disc sclerotized amber-brown, rim with heavily sclerotized brown denticles; disc divided at upper fourth by a transverse slightly arched suture, the rim of the dorsal sclerite without hairs but face of sclerite with two pairs of long dark sub-lateral hairs. Denticles of ventro-posterior sclerite with numerous fine amber-colored hairs, except at extreme posterior apex which is smooth and bilobed and bears ventrally a pair of curved terminal spikes; face of posterior sclerite bears two pairs of long dark hairs in a submedian trapezoid. Face of shield rather smooth, not as rough as in other species. Trunk of eighth segment anterior to shield bears long brown hairs as follows: two sublateral pairs on anterior side of dorsal sclerite of disc near margin, two pairs at extreme tips of dorsal sclerite, four sublateral pairs on ventral margin of trunk of eighth segment anterior to genital lobes, a pair about halfway back near dentated margin of posterior sclerite of disc, and about eight pairs in a straggling line on each side of genital lobes to near apex of disc.

Material examined: Kauai: From the H.S.P.A. Exp. Sta. collection: 1 male, 1 female, Kilauea, Kauai, August 2, 1909. From

the Bishop Museum collection: 1 male, Kilauea, August 2, 1909, Terry, coll. Wirth collection: 1 male, 1 female, many larvae, 2 pupae, Kokee, Kauai (4000 ft.), September 6, 1946, W. W. Wirth (falls at tunnels into Kauaikinana stream); 1 male, 1 female, Kokee stream (3500 ft.), September 6, 1946, W. W. Wirth (at falls into Waimea Canyon). *Oahu*: 8 males, 2 females, 10 larvae, 1 pupa, Kaluanui Valley (2000 ft.), May 14, 1946, W. W. Wirth (above Sacred Falls).

T. abnormis was taken in the mountain streams of the Kokee region on Kauai, where it occurred together with the much larger and more hairy *hirtus*. No unusual habits were noted for *abnormis*, while collecting the few Kauai specimens; the paucity of material collected was not due to its rarity, but to the great physical difficulty in gaining access to the falls and rapids of the streams draining the untraveled mountainous forests at the head of the rugged 2000-3000 feet deep Waimea Canyon. With the watershed receiving 500-600 inches of rainfall annually, the streams are large and numerous.

On Oahu, *abnormis* was collected from Kaluanui Valley above the famous Sacred Falls, probably the wettest locality on the island. It is interesting to note that in the adjacent Punaluu Valley, next toward Honolulu, two *Telmatogeton* specimens which were collected in an irrigation flume were *fluviatilis*, a species widespread in the Koolau Mountains. It is believed that *T. abnormis* is the ancestral form of fresh-water *Telmatogeton*; it is very close to the marine *japonicus* from which it probably was derived; in turn the Oahu species *fluviatilis* and *williamsi* differ but slightly from *abnormis*, while *torrenticola* and *hirtus* are further removed.

The male tarsal claws of *abnormis* are not as figured by Terry, the claws of all legs being alike with the anterior claws bifid at about halfway, the posterior claws bifid near base, in this respect resembling *japonicus*. Other useful characters of *abnormis* are the gradually tapering, rather short seventh antennal segment; normal vestiture, wing venation and male genitalia; bluntly tapering female genital segment; small anal gills sometimes present in the larva; and the extensive shagreening of the preapical abdominal segments of the pupa, especially the seventh tergite.

GROUP B

6. *Telmatogeton japonicus* Tokunaga.

Telmatogeton japonicus Tokunaga, Philippine Jour. Sci., 51: 95, 1933 (Japan; male, female; seashore between tidemarks); *idem*, 57: 491, 1935 (description and figures of immature stages; biology); Biogeographica 2: 38, 1937 (additional Japanese records).

Male.—Length of body, 3-4 mm.; wing, 2.5-3.5 mm.; breadth of wing, 0.6-0.8 mm. General color brownish black, thorax and abdomen pruinose; head, humeral angles of mesonotum, pleura, scutellum, legs and genitalia brown; wings smoky brown; halteres pale brown.

Antenna (fig. 5a) 7-segmented; basal segment large, subcylindrical, about as long as broad, its diameter about twice that of distal segments, with many long setae; segments 2 to 7 of about equal diameter; second segment about twice as long as broad, constricted at middle; segments 3 to 6 subspherical; apical segment about two and a half times as long as wide at base, tapering on distal half to a rounded tip about half the diameter of proximal portion, tip darker than proximal portion; distal six segments without setae except one or two at base and a very fine hair at tip of seventh segment; entire antenna densely pubescent, distal six segments with numerous sensory pits; ratio of lengths of antennal segments, beginning proximad, 30:25:10:10:10:10:27. Maxillary palpi (fig. 5b) two-segmented, setigerous, the proximal portion bulbous, distal portion about half as broad, thumb-shaped, occasionally the segmentation incomplete. Paraglossae small, oval, setigerous. Posterior edge of clypeus and posterior border of eyes with long black setae.

Lobes of pronotum with three to five setae. Mesonotum large, with 3-5 setae in each subdorsal row, a row of 2-6 setae above wing base, and from 2-10 setae in a pre-scutellar patch, all these setae long and black and arising from light-colored integumental spots. Scutellum with 20-30 long setae, these about as long as the length of scutellum; postscutellum without setae; pleura also bare.

Wings with radial veins infuscated; numerous short spines along costa, about 13 spines on R_1 , 2 on R_2 , and about 7 on R_{4+5} ; other veins bare; a fringe of short fine hairs on posterior margin from anal angle to tip; squama fringed with about 25 long hairs. R_1 short, entering costa at a little less than half the length of R_{4+5} , which is gently curved, entering the costa slightly before wing-tip; M almost straight, very slightly sinuous; Cu downcurved at base, Cu_1 curved, reaching wing-margin half-way between ends of M and Cu_2 ; Cu_2 curved strongly at apical three-fourths to meet wing-margin at right-angles; cross-vein $r-m$ oblique, base before middle of wing; fCu slightly distad of base of $r-m$. Relative lengths of R , R_1 , R_{4+5} , base of M , and distal section of M , 8:4:9:7:11 respectively.

Legs long; relative lengths of segments from coxa distad, 3:1.2:10.5:10:5.5:3:1.2:1.1:1.8 on front legs, 3:1.2:16:11.6:4.5:2:1:1.8 on middle legs, and 3:1.2:15.5:11.5:6:3.2:1.2:1.1:1.7 on hind legs. Coxae large; trochanters simple; front femora markedly clavate at base, posterior femora slenderer; apical tibial spines one on fore and middle legs, two on hind legs, pubescent at base, bare apically. Last tarsal segment (fig. 5c) deeply trilobed, lateral lobes about a third as long as median lobe, which is about twice as long as wide; empodium large, pectinately plumose. Tarsal claws alike on all legs, unevenly bifid; the anterior claws of each leg bifid at distal three-fourths with the pectinate outer process about twice the length of the sharp inner process; the posterior claws bifid at proximal third, the pectinate lateral process about half the length of the long sharp inner process. Each claw with a lanceolate hyaline lamella arising mesad at base; a long spine arises from a long tubercle laterad of each claw between lateral and median tarsal lobes. Anterior surfaces of coxae, trochanters, and all of femora, tibiae, and tarsi setigerous; those of coxae particularly large and dense, and setae of all femora, tibiae, and tarsi relatively long, about as long as diameter of tarsal segments.

Abdomen sparsely covered with setae, those of tergites I-IV much longer; light-colored ocellate spots at bases of setae arising near pleural sutures. Male genitalia rotated variably; basistyles stout, truncated, with a small setigerous lobe on mesal side near base, with long setae ventro-laterally becoming very small and fine on dorso-mesal surface; dististyles oval, flattened, with fine setae, these directed proximad on flexor surface; phallosome conical,

directed dorsad from between bases of basistyles, closely guarded by a pair of hyaline sclerotized plates with which it is fused on basal two-thirds; connected at base with a pair of sclerotized hyaline plates which in turn articulate with the dorsal articulation of the basistyles and the proximal ends of the prominent internal parameres. Anal tube prominent, membranous, arising at base of eighth tergite.

Female.—Similar to the male with the following differences: Wing broader than in male and may or may not reach tip of abdomen. All tarsal claws long, pointed, simple, not bifid. Eighth abdominal segment triangular in outline, about half again as long as high, tapering, laterally compressed; cerci long, ovoid and pubescent.

Larva.—(from Tokunaga, 1935) Color semi-hyaline pale-green to greenish-brown, setae of body reduced. Head flattened subcylindrical with narrowed anterior nose-like projection, color brown, darkened along occipital foramen, cephalic margin, lateral margins of front, and base of mentum; integument with pebble-grained thickenings. Eyespots present and irregular. Antennae small and four-segmented, proximal segment stout, about twice as long as broad and subequal in length to remaining distal segments; second segment twice as long as wide, third and fourth minute; a biramous membranous Lauterborn's organ as long as distal three segments combined borne at apex of proximal segment; second segment also bears a number of minute apical sensory spinules. Frons broad and shield-shaped, with two pairs of small setae near the anterior corners along the lateral margins. Vertex with a pair of lateral setae behind antennae and a pair along frontal suture just behind widest point of frons. Clypeo-labrum with a small median posterior transverse post-clypeal sclerite and a very small semicircular pre-clypeal sclerite; the lateral and cephalic margins strengthened and roundly arched ventrad in an overhanging lip; three pairs of long sub-lateral setae on dorsal aspect.

Extreme cephalic margin of labrum with a variety of stout pegs and spines mesally and a pair of lateral brushes of fine fringed hairs; a pair of stout premandibles with flattened tri-lobed apices are articulated on ventral face of labrum. Mandibles stout and heavily sclerotized, with seven sharp darkened teeth on distal third; a stout hyaline distally-directed appressed spine arises near proximal tooth; a compact bristia of about six long hairs near base on dorsal face and two long hairs on ventral face of each mandible. Maxillae triangular, the mesal apex with a beard of long setae and fine hairs, the short unsegmented palpus borne about midway on anterior margin, the margin laterad of palpus fringed with close-set stout pointed spines; the ventral surface of each maxilla with three pairs of long setae. The hypopharynx consists of a transverse lobe with a dense apical fringe of long feathered hairs supported by two long narrow sclerotized arms forming the arms of a V. The mentum is dark and highly sclerotized, 11-toothed, the median tooth largest (relatively small and sharply pointed compared with other species), the lateral teeth becoming progressively shorter and smaller.

Thorax and abdomen with the setae minute, except for the two pairs of long caudal setae on the ninth segment. Anterior pseudopod shallowly bilobed, each lobe with the usual apical crown of narrow hooks. Posterior pseudopods each with 19 stout curved simple hooks in three irregular rows at apex. Anal gills lacking.

Pupa.—(after Tokunaga, 1935) Of the usual shape for the genus with the following specific characteristics: Head not distinctly bilobate, with a pair of prominent setae arising mesad of bases on antennae. Prothoracic respiratory organs broad and flattened, curved and tapering to tip, with the small spiracle dorsally situated near lateral margin at proximal third. There is a pair of anterior setae and two pairs of posterior setae just mesad of the respiratory horns; a pair of setae just mesad of wing bases, and two pairs of minute and one pair of larger submedian pre-scutellar setae. Each of the

first seven abdominal tergites and sternites with several minute setae, a large oval brown shagreened area present on third sternite, and small shagreened patches at the caudal ends of the U-shaped sclerotized lines on segments III-VI. The flattened terminal abdominal disc is rounded, slightly oval in outline, more so in the female, with transverse arcuate suture at the upper fourth. The dorsal sclerite bears many coarse denticles on the rim and four long submarginal hairs on the face; the posterior sclerite bears a fringe of many fine hairs on the thickened margin except at extreme caudal fifth, which is bilobate and bears two strong ventral spines; there are two pairs of long hairs in a submedian trapezoid on the face of the posterior sclerite with two short longitudinal infuscated lines between them. The face of the dorsal sclerite of disc is covered with minute pits and the posterior sclerite is densely covered with minute spinules and scattered spines. The unspecialized portion of the eighth segment is provided ventrally with five pairs of setae along its posterior border laterad of the genital lobes in the male, three pairs in the female; there are two pairs of sublateral setae and two pairs of setae at the extreme lateral ends of the dorsal sclerite of disc on its anterior side; the ventral side of the posterior sclerite bears seven scattered long hairs on each side of the genital lobe in the male, eight in the female. There are four small setae at the base of the female genital lobes, those of the male are bare.

Material examined: 1 male, 1 female, Hilo, Hawaii, December 19, 1945, light trap; 42 males, 10 females, Hilo, Hawaii, February 27, March 2, 6, 1946, W. W. Wirth (scampering over wave-drenched boulders on bay-front at park).

The Hawaiian specimens agree closely in every character studied with Tokunaga's excellent descriptions and figures of *T. japonicus*, and it can only be concluded that this Japanese species, like *T. pacificus*, enjoys a wide distribution across the central Pacific. It is particularly interesting to note that the marine Hawaiian *Telmatogeton* are related to the Oriental species rather than to the Australasian counterparts, *T. australicus* from Australia and *T. pusillum* from the Marquesas Islands. There is a distinct possibility, due to short descriptions, which cannot be resolved without examination of the types, that *pusillum* may be the same as *pacificus*.

The Hilo material was collected from boulders on the bay-front in a limited area near the outlet of a large storm-sewer, with a heavy growth of the algae *Ulva* sp. and *Enteromorpha* sp., indicating that the water was of considerably lower salinity than pure sea water. Since Tokunaga (1935) found *japonicus* always associated with the algae *Ulva pertusa*, *Enteromorpha compressa*, and *Monostroma* sp. on the Japanese coasts, and his excellent detailed biological account of its habits there checked with all of the limited observations made by the writer on the Hilo examples, there is abundant confirmation for the morphological identity of the Hawaiian insects with *japonicus*.

That the Hawaiian *japonicus* is nocturnal is indicated by the capture of adults in a light trap operated several hundred yards inland from the beach; other adults were captured while resting on and scampering over the boulders at the hours of 4 to 5 P.M. and 8 to 9 A.M., the only times that collections were made. Other insects associated with *japonicus* on the algae-covered boulders

were *Scatella sexnotata* Cresson and *Canace nudata* Cresson (Ephydridae), *Cymatopus acrosticalis* Parent (Dolichopodidae), *Dasyhelea calvenscens* Macfie (Heleidae), and *Telmatogeton pacificus* Tokunaga, *Thalassomyia setosipennis* Wirth, and an undescribed species of *Clunio* (Tendipedidae).

7. *Telmatogeton australicus* Womersley.

Telmatogeton australicus Womersley, Rec. S. Australian Museum 5: 441, 1936 (Sellick's Beach, Noarlunga, So. Australia; male, female, larva, biology).

According to Womersley's description, *T. australicus* is quite close to *T. japonicus* from Japan and the Hawaiian Islands. The salient characteristics of *australicus* appear to be: 1) size moderate, length 3.0 mm., wing 4.0 mm.; 2) color brownish with lighter and darker markings as in *japonicus*, wings pearly gray; 3) antennae with last segment twice as long as broad at base, tapering to tip which is not marked off (Womersley's figure, however, shows the seventh segment rather oval and not tapering); 4) eyes large, surrounded with fairly long numerous setae; 5) mesonotum without discernible setae; scutellum with only 6 setae; 6) wings with fCu slightly distad of r-m, about 20 setae on radius, 6 on subcosta; 7) trochanters simple, femora clavate at base; 8) tarsal claws of male bifid almost to base (apparently from Womersley's figure the anterior and posterior claws are asymmetrical with the pectinate outer arm longer on the one, the sharp inner arm longer on the other), with adjacent membranous lanceolate plates, empodium long and plumose; 9) abdomen with sparse short hairs; 10) male genitalia as usual, of *japonicus* type. The most important characters which would separate *australicus* from *japonicus* are the reduction in setae on the thorax and scutellum, the shorter last antennal segment without darkened tip, and slight differences in the male tarsal claws in the Australian species.

The larva of *australicus* resembles others of the genus generally, size 4-5 mm. (? immature); color whitish green, head brown, highly sclerotized, non-retractile. Frons oval, widest before middle, with a pair of lateral subanterior setae; vertex with two setae and an eyespot on each side at extreme lateral margin, also four pairs of pores situated along epicranial suture; clypeo-labrum dorsally with three pairs of setae; antennae four segmented, the first segment half again as long as wide, second similar but smaller, distal two segments minute; mandibles 5-toothed, mentum with 11 teeth, the median tooth broad; setae of body minute, last segment with the usual two pairs of long setae; anterior and posterior pseudopods of usual form.

Womersley remarks that *australicus* is a diurnal species, the adults appearing by the thousands on bright sunny days during the summer. They inhabit the outer portions of the reef which are

covered at high tide with about a fathom of water, the adults appearing at low tide, moving rapidly with a hopping movement over the mossy rocks and about the small pools.

GROUP C

8. *Telmatogeton simplicipes* Edwards.

Telmatogeton simplicipes Edwards, Dipt. Pat. & So. Chile, pt. 2, fasc. 5: 305, 1931 (Ancud, Chile; male; algae-covered rocks between tide marks, figures of male genitalia, antenna).

The following characters from Edwards: 1) length, 3 mm., wing 2.3 mm.; 2) head with only a few hairs at sides of frons, hairs around eyes short; 3) antenna with segment I not much longer than broad, hairy, II twice as long as broad, with two hairs near tip, III-VI without hairs but with several short stout sense bristles near tip; VII oval not twice as long as broad, scarcely narrowed toward tip, with two hairs near base; 4) thorax colored as in *trochanteratum*, only 6-8 subdorsal hairs and 3-4 supra-alar hairs; 5) legs with mid-trochanters simple, male claws all alike, bifid from near middle, pectinate outer arm longer than pointed inner arm; 6) wings with 12 hairs on radius; 7) male genitalia with basistyle narrow, apparently of the *pacificus* type, anal tube present.

The relationships of *simplicipes* are not clear. The antenna figured would not be close to any known species. The male genitalia is allied to that of *pacificus*; also the condition of the male tarsal claws. The condition of the empodium or the position of the cubital fork in relation to the cross-vein is not stated.

9. *Telmatogeton pacificus* Tokunaga.

Telmatogeton pacificus Tokunaga, Mushi, 8: 15, 1935 (Japan; female); Biogeographica, 2: 34, 1937 (male; Japan).

Telmatogeton pusillum Williams (not Edwards), Proc. Haw. Ent. Soc., 12: 166, 1944 (Oahu, Hawaiian Is.; notes on breeding habits).

Male.—Length of body, 2-3 mm.; wing, 1.2-2 mm.; breadth of wing, 0.4-0.6 mm. General color brownish; mesonotum with grayish pruinescence; in freshly preserved alcoholic specimens mesonotum with longitudinal space between subdorsal setae and sides caudad of a straight diagonal line about one-fourth way back dark brown, basal antennal segments, vertex, scutellum, postscutellum, tips of femora and bases of tibiae brownish, other parts pale brown; halteres, tibiae, and tarsi often yellowish-white; wings pale smoky brown; dried specimens darker with markings indistinct.

Head small, subspherical; eyes small and widely separated. Antennae (fig. 5b) 7-segmented, comparatively short, basal segment large, sub-cylindrical, slightly longer than broad, its diameter about twice that of flagellar segments, with many long dark setae; second segment about twice as long as broad, somewhat constricted in middle with two long setae; segments 3 to 6 sub-spherical, without setae; distal segment about twice as long as wide at base, suddenly narrowed distally to a small knob-like tip, with one long

seta; ratio of length of antennal segments beginning proximad, 30:30:11:11:11:11:25. Palpi (fig. 5e) elongated and incompletely segmented, constricted in middle, about four times as long as broad, with several scattered long setae. Paraglossae small, subcylindrical, about twice as long as wide, also constricted in middle. Clypeus and vertex dark, with many long black setae; also a circumocular ring of long black setae which curve to meet over the eyes.

Lobes of pronotum with one seta. Mesonotum strongly arched dorsally and overhanging the head anteriorly; about 7-10 long black setae in each sub-dorsal row and 3-6 setae in a supra-alar group, arising from prominent light-colored ocellate spots. Scutellum with about 10 long setae; the longest of these as well as the mesonotal setae are about as long as the length of the scutellum.

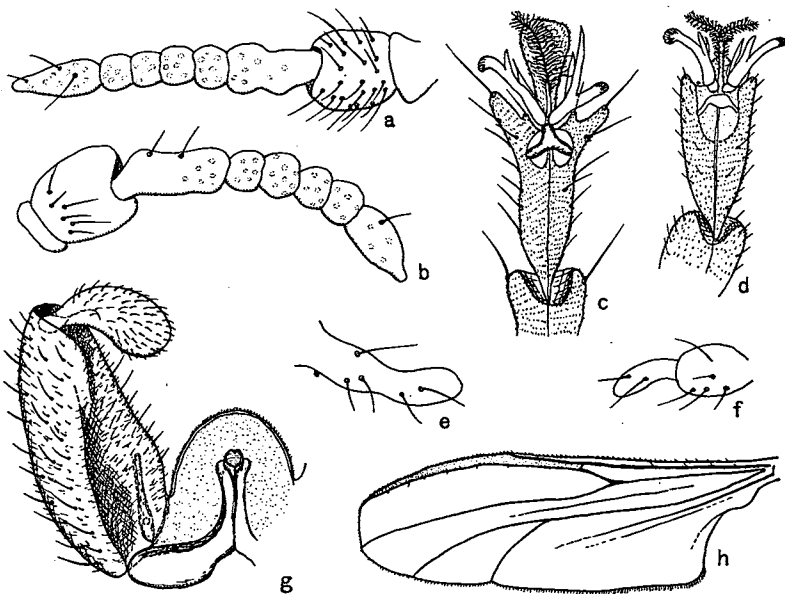


Figure 5. a) antenna, *T. japonicus*; b) antenna, *T. pacificus*; c) fifth tarsal segment of *T. japonicus*, ventral view; d) same, *T. pacificus*; e) palpus, *T. pacificus*; f) palpus, *T. japonicus*; g) male genitalia, *T. pacificus* (right basistyle removed, dorsal view); h) left wing, *T. pacificus*.

Wings (fig. 5h) appearing light smoky grayish brown; costa with close-set small spines for entire length; three long hairs on base of radius, about 9-10 spines on R_1 , 11 on R_{4+5} ; other veins bare. R and R_1 heavy, apparently continuous and straight, ending in costa about midway of wing; R_{4+5} gently curved, ending in costa just before wing-tip. M slightly sinuous, ending at lower edge of wing-tip; Cu_1 gently curved to meet wing-margin at a 55° angle; Cu_2 strongly curved to meet margin at right angles. Cross-vein $r-m$ exceptionally far proximad, at slightly more than one-third the distance to wing-tip, thus fCu is much distad of $r-m$. Relative lengths of R and R_1 combined, R_{4+5} , base of M , and distal section of M , 34:28:20:33 respectively. Anal angle generally 90° , though in occasional specimens the anal angle is markedly obtuse, in these the wings are otherwise quite broad and rounding.

Legs long, relative lengths of segments from coxa distad, 2.5:1:7.4:6.8:4:1.6:1:0.9:1 on front legs, 2.3:1:11.2:7.6:3.8:1.4:1:0.8:1 on middle legs, and 2.5:1:10.6:7.6:4.2:2.2:1:0.8:1 on hind legs. Coxae large, trochanters simple, femora clavate at base, the front pair remarkably so and the posterior four but slightly; apical tibial spines small, single on all legs, pubescent at base, bare apically. Last tarsal segment (fig. 5d) trilobed, the lobes relatively short, especially the lateral pair which are scarcely perceptible. Tarsal claws alike on all legs, symmetrical, bifid at basal third, lateral tooth long and rounded pectinate at tip, inner tooth about half as long, slender and sharp. Each claw with a lanceolate hyaline lamella arising mesad at base; empodium bifid at distal half, plumose. Anterior surfaces of coxae, trochanters, and all of femora, tibiae, and tarsi setigerous, those on coxae denser and longer, others sparser and relatively short.

Abdomen sparsely covered with setae arising from light-colored ocellate integumental spots, those of anterior tergite quite long, progressively shorter on posterior tergites. Male genitalia (fig. 5g) turned through about 85°; basistyles relatively slender, widely separated at base by the phallosome complex, without lobe at base of dorso-mesal surface, with scattered hairs latero-ventrally and numerous short fine setae on mesal surface; dististyles short, oval, flattened, thickly covered with fine curved setae; phallosome large, projecting far dorsad, with a pubescent conical base ventrally and a small membranous anteriorly directed antero-dorsal lobe (as seen in deep fluid mounts); parameres slender, heavily sclerotized, directed into interior of basistyles. Anal tube not developed.

Female.—Similar to male, with following differences: Wing not nearly reaching tip of abdomen. All tarsal claws long and slender, much longer than those of male, simple and pointed. Eighth abdominal segment much narrowed and produced, the cerci long and slender.

Larva.—Length mature, about 7 mm.; head capsule 0.55 mm. long by 0.37 mm. wide. Color light greenish when mature, head capsule amber-brown, darker along cervical border and mandibular and labial teeth; hooks of pseudopods brownish.

Head barrel-shaped slightly flattened dorso-ventrally, lateral margins subparallel for most of length; integument of head with pebble-grained sculpturing, most pronounced in region of clypeo-labrum. Frons about twice as long as wide, widest at anterior third, anterior border truncated by the transverse fronto-clypeal suture which is about five-sevenths as long as greatest width of frons; frons roundly pointed caudad at junction of arms of epicranial suture. Clypeus transverse, apparently fused with labrum, the two forming a cowl which folds ventrad along a straight line on the anterior margin and is continued on the ventral side as the labrum. The antennae (fig. 6c) are small and borne laterally at level of fronto-clypeal suture; the barrel-shaped proximal segment is as long as distal segments combined, the second segment is about half as long and a third as broad as first and bears apically two minute distal segments and several minute sensillae adjacent to these; a slender membranous biramous Lauterborn's organ adjacent to and as long as the distal three segments together is also borne at the end of proximal segment. A pair of small eyespots is located laterally on head just behind antennae. The dorsum of the head bears small hairs as follows: a sublateral pair on anterior extremity of clypeo-labrum, a lateral pair at anterior corners of frons, a second pair on lateral margins of frons just behind level of eyespots; another pair adjacent to these across frontal suture; a lateral pair just ventral to eyespots; a pair just laterad of frontal suture about a third-way from caudal extremity of frons, a lateral pair just ventral to these, and a posterior pair situated well laterad about midway of the median arm of the epicranial suture.

Labrum, the dorsal aspects of which are discussed above, folded downward and caudad, the ventral portion greatly narrowed caudo-mesad, with very

heavily sclerotized emarginate lateral borders; a pair of long fine sublateral hairs directed antero-ventrad just below and mesad of the antero-dorsal pair mentioned above; a V-shaped row of about six setae-bearing tubercles mesad on the ventral margin; the paired flattened simple premandibles (fig. 6d) are borne laterad of and posterior to the lip, with the flattened tri-dented apices directed mesad. The mandibles (fig. 6b) are large, heavily sclerotized, with six teeth on distal half, two long ventral hairs and a brush of about six long hairs midway on dorsal margin. The maxillae (fig. 6a) consist of a simple flattened plate about three times as long as wide, bearing on the ventral surface beginning mesad a group of fine long slender combs directed toward the mentum, a group of blunt pegs, a short unsegmented palpus with a group of sensillae in the center of the truncated apex; two small hairs, a patch of small flattened setae at margin and one or two large hairs from a large tubercle near lateral margin. Mentum (fig. 6e) about as long as broad with a rather narrow long rounded median tooth, five sharp progressively smaller lateral teeth on each side. The hypopharynx consists of a small lobe thickly bearded with fine hairs, long flattened setae, and short spines supported by two slender heavily sclerotized arms in a V-shaped bridge.

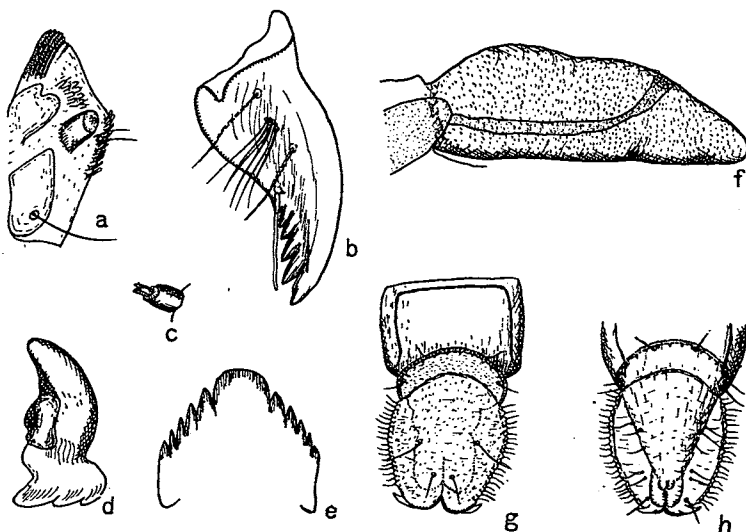


Figure 6. *T. pacificus*, larval and pupal details. Larva: a) left maxilla, ventral view; b) left mandible, dorsal view; c) antenna; d) premandible; e) mentum. Pupa: f) left prothoracic respiratory organ, dorsal view; g) terminal abdominal disc of male pupa, dorsal view; h) same of female pupa, ventral view.

Prothoracic pseudopods bilobed at tip, each lobe with a crown of many amber-colored hooks increasing in size from minute spines well up on posterior side of lobe to long slender curved hooks on anterior margin of apex. Thoracic and abdominal segments at most with a few minute hairs. Ninth abdominal segment rounded dorsally, indistinctly segmented into a ventro-posterior portion bearing the anus between a pair of short pseudopods; these each with a posteriorly interrupted crown of about 12-15 strongly curved hooks at apex; dorsal portion of ninth segment bears a sublateral caudal

pair of prominent double hairs. Hooks of both anterior and posterior pseudopods quite simple, without secondary teeth. Anterior pseudopods are retractile by inversion.

Pupa.—Length, about 3.4 mm. Color light, becoming darker as imago matures. Mesothorax arched antero-dorsally, a pair of prominent horn-shaped respiratory organs (fig. 6f) arising from humeral corners, projecting antero-dorsally over head, spiracle opening laterally at anterior third or fourth, the trachea within lobe slender and faintly marked; a long hair arises just mesad of the base of each antenna; two long hairs on humeral corner just dorsad of base of each respiratory horn, a long hair just anterior to each wing base, and two pairs of submedian hairs between wing bases.

Segments III to VI of abdomen with shagreened patches on anterior fourth of tergite and sternite within the bases of the U-shaped sclerotized lines, and at the posterior end of each lateral arm of the U; segments I-VII without evident hairs or setae. Terminal abdominal disc elongate (figs. 6g, 6h), about half again as long as wide, transverse suture at dorsal sixth of face of disc; dorsal portion with about 12 large sharp heavily-sclerotized denticles but without hairs; rim of posterior portion of shield with rounded evenly-spaced denticles each with a single long amber hair except at posterior extremity which is divided into two bare rounded lobes, each with a sub-apical ventral recurved hook. Face of dorsal sclerite of disc with a single long hair near rim at each lateral corner; posterior sclerite with four long hairs widely spaced in a sub-median trapezoid. Trunk of eighth segment anterior to the disc bears long black hairs as follows: a dorso-lateral pair near rim of disc; two hairs near each end of transverse suture of disc, a long hair on each side about halfway back near rim of posterior sclerite, and a row of four or five hairs just laterad of lobes of gonostyles.

Material examined: From the Bishop Museum collection: 4 males, Waianae, Oahu, November 2, 1935, F. X. Williams (on tidepool rocks). From the H.S.P.A. Exp. Sta. collection: 15 males, 4 females, Waimanalo Bay, Oahu, June 2, 3, 1936, F. X. Williams (algal tide rocks) (Note: 1 pin with 2 males, bears F. W. Edwards' determination label "*Telmatogeton* ? *pusillum* Edw." These very plainly have bifid empodia). Wirth collection: *Oahu*: 8 males, 1 female, Lanikai, December 29, 1945, W. W. Wirth (on rocks); 8 males, Hanauma Bay, January 4, 1946, W. W. W. (on rocks); 30 males, 20 females, Rabbit Island, August 30, 1946, W. W. W.; 3 males, 1 female, Makapu Point, January 5, 1946, W. W. Wirth; 50 males, females, Makapu Point, April 16, 1946, W. W. W.; Koko Head, February 11, 1946, 38 males, females, April 30, 1946, 50 males, females, 30 larvae, 6 pupae, August 27, 1946, 15 males, 5 females, 10 larvae, 1 pupa, all W. W. W. (on rocks with *Ectocarpus*); 8 males, Waimanalo, February 15, 1946, W. W. W.; 10 males, Kahuku, February 8, 1946; 30 males, females, Waimea, May 2, 1946, W. W. W.; 20 males, females, Waianae, August 28, 1946, W. W. W. (on rocks with *Ectocarpus*). *Hawaii*. 12 males, 5 females, Hilo, March 1, 1946, W. W. W. (on rocks Puumaile coast); 14 males, females, February 27, 1946, W. W. W. (on rocks, bay-front). *Kauai*. 50 males, females, Kilauea Bay, September 8, 1946, W. W. W. (on boulders on beach); 30 males, females, Nawiliwili Bay, September 7, 1946, W. W. W. (on wave-drenched boulders on waterfront and at light).

T. pacificus is found everywhere on the rocks of the Hawaiian seacoasts, the writer having taken it from ten widely distributed localities on Hawaii, Oahu, and Kauai. As stated in the excellent account by Williams (1944) who reported the first observations on this species under the name *pusillum*, it is most common at the upper tide belt on wave-drenched rocks and boulders characterized by a sparse growth of the tufted brownish alga *Ectocarpus* sp. Colonies were also found in bays as at Hilo, Hawaii, and Kilauea and Nawiliwili, Kauai, where a heavy influx of fresh-water from sizeable streams so freshened the shorewater in the bays as to promote heavy growths of the algae *Ulva* sp. and *Enteromorpha* sp. on the littoral rocks. Colonies of *pacificus* were most often found on the rocks and boulders of volcanic origin, but at Maile (Waianae) and Kahuku, Oahu, colonies were found apparently flourishing on wave-worn outcrops of coral rock underlying a narrow coastal plain. These coral outcrops were frequently interspersed with beaches of fine coral sand and supported a straggly growth of filamentous green alga (? *Enteromorpha* sp.). Tokunaga (1937) reports finding *pacificus* associated with the algae *Endocladia complanata*, *Nemalion pulvinatum*, and *Monostroma* sp. in Japan.

10. *Telmatogeton pusillum* Edwards.

Telmatogeton pusillum Edwards, B. P. Bishop Mus. Bull. 114: 88, 1935 (Marquesas Is.; male, female; at light, presumably marine).

T. pusillum is apparently quite close to *T. pacificus*, points of similarity being their small size (wing 2 mm.), light brownish color, short lateral lobes of last tarsal segment, male claws bifid, symmetrical, sharp inner tooth of claw small, and cubital fork much beyond base of r-m.

From the Bishop Museum collection 2 male and 1 female specimens from Vaituha, Eiao, Marquesas Islands, (October 2, 1929, at light, A. M. Adamson, coll.) representing material collected with Edwards' types, were examined. As well as could be ascertained from the study of these pinned, dried specimens, the only differences between these and Hawaiian specimens of *pacificus* are the apparently simple empodium and the sharply bent vein Cu₂ in *pusillum*. The subdorsal setae of the mesonotum stated by Edwards to be "about 20 in each row" are actually 8 or 9 in each row as in *pacificus*.

Previous records of *T. pusillum* from the Hawaiian Islands should be referred to *T. pacificus* as all of about 500 adults taken at 10 scattered localities on Hawaii, Oahu, and Kauai, had the bifid empodium of *pacificus*. The specimens originally sent to Edwards for determination from Oahu were returned marked "*Telmatogeton* (?) *pusillum* Edwards." At present then, *pusillum* is known only from the Marquesas Islands.

GROUP D

11. *Telmatogeton sancti-pauli* Schiner.

Telmatogeton sancti-pauli Schiner, Novara Reise, Zool. 2: 25, 1868 (St. Paul Is.; male, female described, larva and pupa figured); Edwards, Konowia, 7: 236, 1928 (syn.: *Trissoclunio fuscipennis* Kieffer, n. syn.); Hesse, Trans. R. Ent. Soc. Lond., 82: 27, 1934 (larva, pupa described, figured; ecology; South Africa).

Paraclunio fuscipennis Kieffer, Ann. So. Afr. Mus., 10: 259, 1914 (So. Africa).

Trissoclunio fuscipennis Kieffer, Ann. So. Afr. Mus. 17: 523, 1920 (type of *Trissoclunio* gen. n.).

Male.—Length of body, 4.5 mm.; wing, 5.6 mm.; breadth of wing, 1.6 mm. General color dark brown (blackish), most of body pruinose; humeral angles of mesonotum, pale brown, halteres yellowish; wings smoky brown.

Antenna (fig. 7a) 7-segmented, exclusive of the proximal ring-like antennaria; basal segment large, sub-cylindrical, slightly longer than broad, its diameter over twice that of distal segments, covered with many long setae; second segment about twice as long as wide, constricted in middle, the distal portion quite resembling one of the following four segments which are sub-spherical, each with a stout seta; seventh segment about three times as long as broad at base, tapering to tip, with three or four hairs at base; ratio of lengths of antennal segments beginning proximad, 60:40:16:16:16:16:50; entire antenna densely pubescent, apex of II, all of III to VI, and base of VII with numerous sensory pits. Palpi two-segmented, first segment small, variable in shape with a few distal setae; second segment oval, about twice as long as broad, densely setose. Paraglossae about size of distal palpal segment, ovoid, setose. Clypeus dark, with many quite stout long setae. Vertex dark, the setae sparse, but there is around each eye a ring of long stout hairs which curve to meet over the eyes forming a basket-like protection.

Prothoracic lobes small and widely separated, bare or at most with a few minute setae. Mesonotum large, broadly arched anteriorly overhanging the head; broad and flat between wings; setae of mesonotum small, arising from light-colored ocellate spots, restricted to a few (10) in each subdorsal row from humeral fossae to pre-scutellar space, and about 15-20 in a narrow patch above each wing-base. Pleura brownish-pruinose, bare of setae. Scutellum dark brown, convex, about twice as wide as long, with about 50 long dark setae, the longest of these about as long as length of scutellum.

Wings with costa, radius and base of M more darkly infuscated; costa with numerous minute setae its entire length, there are also a few scattered small setae on all branches of the radius; squama with a fringe of rather small hairs. Venation normal, fCu narrow, occurring at or slightly proximad of level of base of r-m; relative lengths of R, R₁, R₄₊₅, base of M, and distal section of M, 20:9:20:18:22 respectively.

Legs long; relative lengths of segments from coxa distad, 6:2.1:17:20:12:4:2.4:1.6:3 on front legs, 4:2.5:22:22:8:3.2:2.2:1.5:2.5 on middle legs, and 6:2.4:24:23:13.5:6:2.3:1.6:2.8 on hind legs. Coxae large, with a dense patch of stout setae distally, these are especially stout and spine-like on front coxae. Trochanters with a dense pad of short stout setae ventrally, the mid-trochanters are swollen with these setae borne on a ventral knob about as high as broad. Remainder of legs evenly clothed with short setae. Apical tibial spines one on each leg. Last tarsal segment (fig. 7d) trilobed, the lobes short, the median lobe not more than half the length of the claws when extended, the lateral lobes about two-thirds as long; empodium large, pectinately plumose from base between the claws. Tarsal claws unevenly bifid,

the lateral tooth pectinate at tip; on the anterior claws the pectinate arm is nearly twice the length of the sharp inner arm while on the posterior claws the sharp inner arm is slightly longer.

Abdomen with small hairs arising from light-colored ocellate spots, these hairs long on first tergite but reduced on other tergites and sternites. Male genitalia (fig. 7c) turned about 15° from horizontal plane and rather stout.

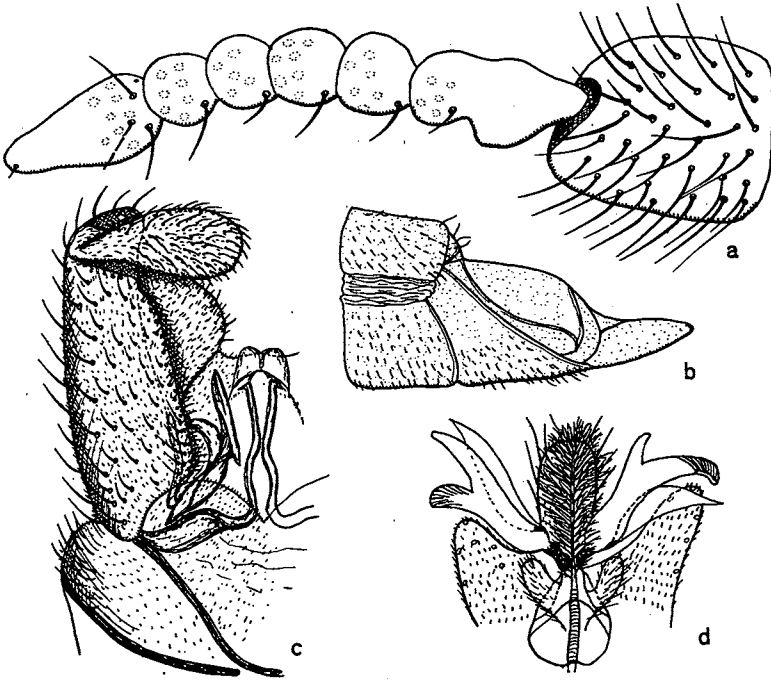


Figure 7. *T. sancti-pauli*. a) antenna; b) terminal segments of female abdomen, left lateral view; c) male genitalia, dorsal view (right basistyle removed); d) tip of fifth segment, right front tarsus, ventral view.

Basistyle about twice as long as broad, mesal face on dorsal side emarginate, the margin densely set with stout setae; the two basistyles fused mesally on ventral side on basal half or two-thirds, the part beyond gradually curved to apex. Dististyles simple, infolded, flattened, ovate, about twice as long as wide, widest on distal third, entire surface covered with fine hairs and pubescence. Phallosome complicated, mesally with two slender sinuous internal sclerotizations with hooked tips, a pair of adjacent long slender saber-shaped laminiform plates with a shorter curving lateral arm; all arising from a common sclerotized basal bridge which also gives rise to the internal parameres at the lateral basal corner of the lateral phallosomal plate. More or less ventral or posterior to the sclerotized parts there is a membranous anterior lobe rounded distally, and a longer hyaline posterior lobe rather truncate, indistinctly bilobed and with many minute teeth at apex. The area anterior to the base of the phallosome on the eighth dorsum is membranous and bears the indistinct membranous anal lobe.

Female.—Similar to the male with the following differences: Midtrochanters with ventral protuberance only about half as high as broad, the setae much smaller. All tarsal claws long, pointed and simple; last tarsal segment more deeply trilobed than in male. Eighth abdominal segment (fig. 7b) laterally compressed, tapering in side view and upcurved to a sharp point formed by the pointed cerci; bare except for fine setae on lower part of eighth sternite. The ovipositor is concealed within the cavity formed between the cerci.

Material examined: 1 male, 1 female, Mouille Point, Cape Town, So. Africa, September, 1933 (hatched from larva). Specimens kindly furnished by Dr. A. J. Hesse of the South African Museum, who published a very detailed study of the immature stages and ecology of this species in 1934. As no readily available description of the adults of *sancti-pauli* seems to exist (Schiner's [1868] was short and in German; Kieffer's [1914] in French) the above description was drawn up from Dr. Hesse's material.

As pointed out by Edwards (1931, p. 306) *sancti-pauli* is quite closely related to *trochanteratum* from Chile. Edwards did not mention it in his comparison, but the mid-trochanters of the male of *sancti-pauli* are enlarged and densely setose ventrally (first noted by Hesse, 1934, p. 36); however in *sancti-pauli* these projections are only about half as long as in *trochanteratum*. Further points of similarity are in the antennal segments III to VI which in both species bear one or two stout dorso-lateral hairs, rather exceptional in the genus; in the last tarsal segment of the male of both species are a pair of small pubescent lobes basad of each claw, the empodium is also plumose to base well proximad of bases of claws and the male tarsal claws are quite similar, at least on the front and middle legs. The most important points of difference are in the last antennal segment which bears a long terminal dark-colored nipple in *trochanteratum*, and in the weaker circum-ocular bristles, narrower basistyle of male genitalia, longer projection of mid-trochanter of male, and shorter vein R_1 in the Chilean species.

Hesse (1934) described the larva and pupa of *sancti-pauli*. The larva when mature measures 8-10 mm.; color various shades of olivaceous green, head brownish with tips of mandibles, eyespots, cervical margin of head, and hooks of posterior pseudopods black. Mandibles with 5 teeth; mentum triangular, the median tooth broad but with sharp-pointed apex, 4 or 5 teeth on each side. Head partially retractile within first thoracic segment; both anterior and posterior pseudopods retractile; anterior pseudopod with many narrow hooklets becoming small spinules posteriorly; posterior pseudopod with a posteriorly interrupted crown of large curved hooks distally; setae of body minute except for the pair of long double hairs at posterior extremity of ninth segment; no gills or spiracles present. The pupa measures 8-9.5 mm.; anterior cephalic margin with two convex rounded lobes, respiratory organs flattened, rather broadly expanded basally, gradually tapering to a blunt tip distally,

the lateral half indistinctly septate; spiracular opening oblique and slit-like, at proximal fourth of lobe. Preapical abdominal segments with a basal transverse shagreened area just behind base of sclerotized U on tergites and sternites, also a shagreened patch at the posterior tip of the lateral arms of the sclerotized U on third to sixth tergites and sternites. Terminal abdominal disc elliptical, more elongated in the female, divided by a transverse arcuate suture, the dorsal sclerite with strongly dentated rim, the posterior sclerite with the emarginate dentated rim bearing tufts of fine long yellow hairs from each tooth except at the bilobed apex, which bears ventrally a pair of curved spines. The face of the shield is heavily sclerotized and roughened, the dorsal sclerite bears two pairs of sublateral long black hairs, the posterior sclerite has two submedian longitudinal impressed smooth lines and two pairs of sublateral long black hairs. The under side of the disc also bears a number of long hairs, about four near each caudo-lateral edge of dorsal sclerite and about twelve laterally along each side of the median genital lobes.

Habitat.—On rocks covered with growth of the algae *Porphyra capensis* and *P. vulgaris* between tide marks, Atlantic and Indian Ocean sides of the Cape of Good Hope and on St. Paul Island, Indian Ocean. The larvae are transitional between the terrestrial and aquatic environments, and cannot stand permanent submergence, but require the moist protection of the periodically-drenched fronds of the algal food-plant. Hesse gives a very excellent discussion of the ecology of the immature stages in his paper.

12. *Telmatogeton minor* (Kieffer).

Paraclunio minor Kieffer, Ann. So. Afr. Mus., 10: 260, 1914 (Mouille Point, Cape Town, So. Africa).

Trissoclunio minor Kieffer, Ann. So. Afr. Mus., 17: 523, 1920 (from *Paraclunio*).

Telmatogeton minus Edwards, Konowia, 7: 234, 1928 (from *Trissoclunio*; ? small form of *sancti-pauli*).

Telmatogeton minor Hesse, Trans. R. Ent. Soc. Lond., 82: 34, 1934 (adults redescribed, figured; larva and pupa described, figured; ecology, So. Africa).

Excellent descriptions and figures of *T. minor* were given by Hesse (1934). A male and two females from Reef Bay, Port Elizabeth, South Africa, collected April 7, 1936 by T. A. Stephenson, were kindly furnished the writer by Dr. Hesse and used in determining the position of *minor* in the key to species at the end of this paper.

The most salient characters of *T. minor* are: 1) small size, body 4 mm.; wing 3-3.5 mm.; 2) extensive pale markings on the blackish brown base color; 3) antenna with basal segment short, seventh

segment short and tapering, apex not marked off; 4) setae of body and wings small and sparse; 5) mid-trochanters without marked protuberance in male; 6) apical tibial spines 1:1:2; tarsal ratio slightly over 0.5 on front and hind legs, much less than 0.5 on mid-legs, mid tarsi being quite short; 7) male claws bifid, anterior and posterior claws sub-equal, pectinate outer arm slightly longer than sharp inner arm in all claws; female claws simple; 8) empodium large, pectinately plumose; 9) wings pearly gray, not darkly infuscated; fCu at about level of base of r-m; 10) male genitalia of the *sancti-pauli* type; female abdomen markedly produced and tapering distally, eighth segment over twice as long as high, cerci long and narrow.

The larvae of *T. minor*, according to Hesse, are about 5 mm. long, quite dark in color (the body dark, the head shining black); the mentum has 11 or 13 teeth, the median tooth rounded; the distal mandibular tooth blunt; and the pseudopods are shown to be retractile but with the normal complement of hooks. The pupae (length 3.5-4 mm.) do not have the anterior cephalic margin bilobate as in *sancti-pauli*, the respiratory lobes are quite broad basally, abruptly tapering to tip with the spiracle at about proximal third; preapical abdominal segments without median shagreened area at bases of segments, but with quite broad lateral shagreened patches at the apices of the lateral sclerotized lines on tergites and sternites; terminal abdominal disc rather longer than broad, especially in the female, divided at dorsal sixth by an arcuate transverse suture, the border of the dorsal sclerite with fine denticles, the margin of the posterior sclerite with the denticles minute and furnished with tufts of very fine short yellowish hairs, the face of the disc not appreciably rugose or wrinkled.

13. *Telmatogeton trochanteratum* Edwards.

Telmatogeton trochanteratum Edwards, Dipt. Pat. & So. Chile, pt. 2, fasc. 5: 305, 1931 (Ancud, Chile; male, female; on seaweed-covered rocks exposed at low tides; figure of antenna, male genitalia and fifth tarsus).

Edwards' description and figure of *T. trochanteratum* are quite adequate to characterize the species: 1) length 2.5-4.5 mm., wing 3.3-5 mm.; 2) long dark hairs at sides of frons and around the eyes; 3) antennae dark except preapical portion of seventh segment whitened, first segment large and densely hairy, second long with two or three hairs near tip, segments III-VI subspherical each with one or two dorso-lateral hairs, seventh segment about twice as long as wide with three hairs near base and a deep subterminal constriction and a conspicuous darkened slightly swollen apical stylet; 4) mesonotum orange-yellow on shoulders and sides, brownish near wings and on scutellum, blackish pruinose mesad, 8-10 short subdorsal hairs, 6-8 short supra-alar hairs; 5) mid-trochanters of male

with a thumb-like projection fully twice as long as broad, rounded at tip, and pubescent, in female with a slight knob; 6) tibial spurs 1:2:2:7) tarsal claws of male bifid, anterior claws of front and middle legs with outer pectinate arm much longer than sharp inner arm, posterior claws with pectinate arm reduced, on hind legs the sharp arm is much longer than the pectinate arm on all claws; female claws simple; 8) wings with about 50 setae on radius, R_1 much less than half as long as R_{4+5} , membrane with hexagonal pattern of bare lines and with microtrichiae of two different lengths; 9) male genitalia not inverted, of *sancti-pauli* type, anal tube absent.

Allied to *T. sancti-pauli*, but differs as discussed under that species. It is interesting to speculate on how these allied species came to be separated at the southern extremities of two now widely separated southern hemisphere continents.

KEY TO THE SPECIES OF *Telmatogeton*

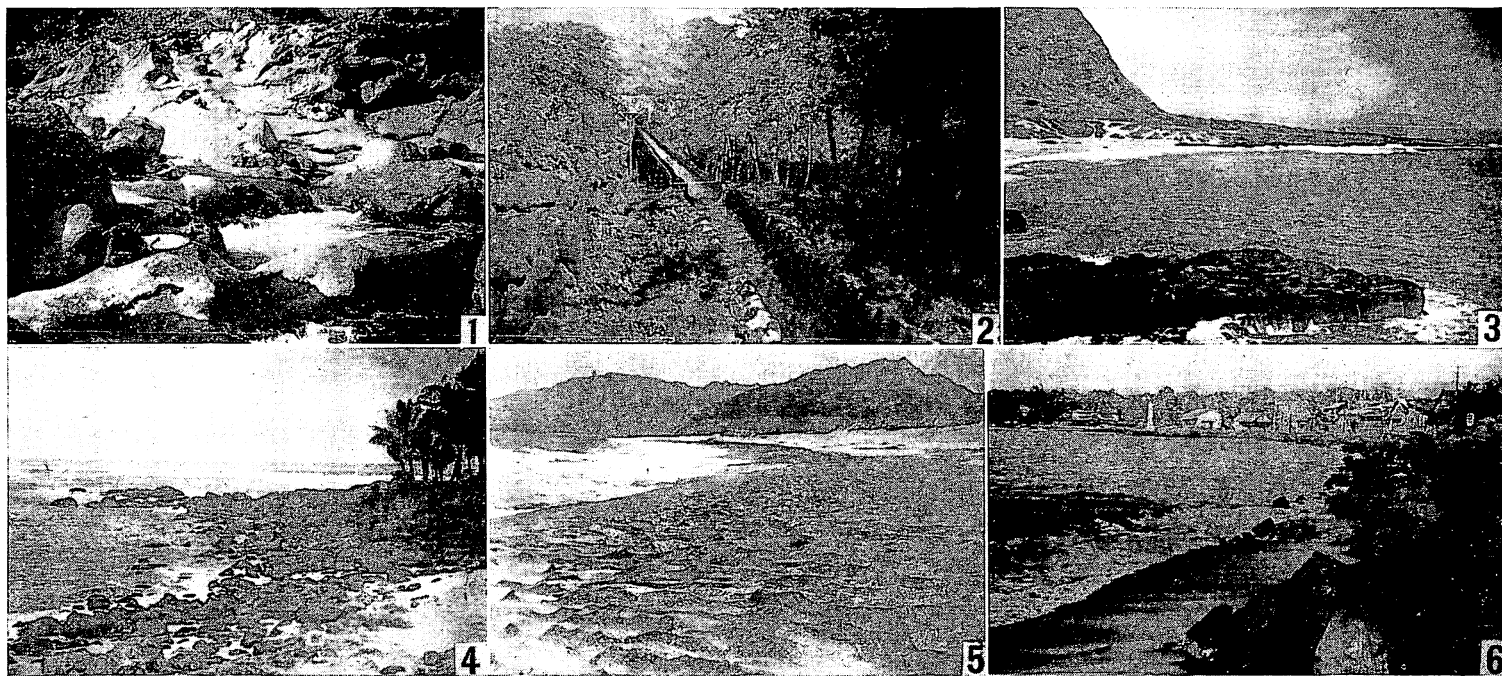
Adult Males:

1. Tarsal claws simple; not bifid, similar to female claws (fig. 1d)..... 2
 Tarsal claws bifid, each divided into a pectinate lateral arm and a sharp pointed inner arm (figs. 2, 4, 5, 7)..... 3
2. Hairy vestiture of entire body, especially the legs, remarkably dense and in the male quite long (hairs of legs 2-6 times as long as diameter of tarsi) (fresh-water; Kauai,—Hawaiian Islands)..... *hirtus* sp. n.
 Vestiture normal, short (fresh-water; Hawaii, Maui, Molokai,—Hawaiian Islands)..... *torrenticola* (Terry).
3. Claws symmetrical, anterior and posterior claws of each leg similar (figs. 4d, 5d)..... 4
 Claws asymmetrical, anterior and posterior claws of each leg dissimilar (figs. 2c, d, e; 5c; 7d)..... 7
4. Claws with pectinate arm much longer than sharp inner arm..... 5
 Claws with pectinate arm much shorter than inner arm (fig. 4d) (fresh-water; Oahu,—Hawaiian Islands)..... *fluviatilis* sp. n.
5. Last antennal segment narrowed to a terminal nipple-like tip (fig. 5b); cross-vein r-m much proximad of middle of wing (fig. 5h); lateral lobes of fifth tarsal segment short, less than half the median lobe (fig. 5d)..... 6
 Last antennal segment oval, scarcely tapering to tip; cross-vein r-m at about middle of wing; lateral lobes of fifth tarsal segment longer, at least half the median lobe (marine; Chile)..... *simplicipes* Edwards.
6. Empodium bifid at tip (fig. 5d); vein Cu_2 only gently curved (marine; Japan, Hawaiian Islands)..... *pacificus* Tokunaga.
 Empodium simple; vein Cu_2 sharply bent and recurved (marine; Marquesas Islands)..... *pusillum* Edwards.
7. Anterior claws with pectinate arm at least a third as long as the sharp inner arm..... 8
 Anterior claws with pectinate arm reduced to a basal knob, posterior claws with sharp inner arm small, arising three-fourths way on the side of prominent pectinate arm (fig. 2c, d, e) (fresh-water; Oahu,—Hawaiian Islands)..... *williamsi* sp. n.

8. Antennal segments III-VI each with one or more dorso-lateral hairs (fig. 7a); mid-trochanters ventrally with a densely pubescent knoblike projection (in female with a slight raised knob)..... 9
- Antennal segments III-VI without hairs; mid-trochanters not swollen ventrally, simple..... 11
9. Projection of mid-trochanters at least twice as long as broad; last antennal segment with nipple-like tip about as long as basal part of segment; circum-ocular bristles not strong (marine; Chile)..... *trochanteratum* Edwards.
- Projection of mid-trochanters about as long as broad; last antennal segment tapered at tip, nipple absent; circum-ocular bristles strong, meeting over eyes..... 10
10. Large species (wing 5-6 mm.); color dark, mostly blackish, wings smoky brown; setae of body and wings numerous and strong (50 on scutellum); (last abdominal segment of female about one and a half times as long as high [fig. 7b]) (marine; So. Africa, St. Paul Is.)..... *sancti-pauli* Schiner.
- Small species (wing 3-3.5 mm.); color light, mostly brownish, wings pearly gray; setae of body and wings sparse and small (12 on lateral edges of scutellum); (last abdominal segment of female long and tapering, over twice as long as high) (marine; So. Africa)..... *minor* (Kieffer).
11. Color brownish, median mesonotal stripes blackish, sides pale brown; 20-25 setae on radius..... 12
- Color mostly black, light brown markings on mesonotum confined to a small humeral area; wings dark smoky brown; 7-10 setae on radius, 30 setae on scutellum (fresh-water; Oahu, Kauai, Hawaiian Islands)..... *abnormis* (Terry).
12. Scutellum with 20-30 setae; mesonotum with 2-10 prescutellar, 3-5 subdorsal, and 2-6 supra-alar setae; first antennal segment with many large setae, last segment with tip darkened, two and a half times as long as broad (marine; Japan, Hawaiian Islands)..... *japonicus* Tokunaga.
- Scutellum with only 3 setae on each lateral margin; mesonotum without discernible setae; first antennal segment with six setae, last antennal segment twice as long as broad, tip not darkened (marine; So. Australia)..... *australicus* Womersley.

Larvae:

1. Three short anal gills present..... 2
- Anal gills absent..... 3
2. About 17 hooks on posterior pseudopods; setae of body reduced, abdominal segments each with 2-3 pairs of minute lateral setae..... *abnormis* (Terry) (in part).
- From 20 to 25 hooks on posterior pseudopods; setae of body well developed, abdominal segments each with 4 pairs of fairly long black setae..... *hirtus* sp. n.
3. Posterior pseudopods each with at least 17 hooks..... 4
- Posterior pseudopods each with 12-15 hooks..... *pacificus* Tokunaga.
4. Mandibles with 5 teeth..... 5
- Mandibles with 7 teeth (posterior pseudopods each with about 19 hooks)..... *japonicus* Tokunaga.
5. First segment of antenna short, about one or one and a half times as long as broad..... 6
- First segment of antenna about twice as long as broad..... 7



EXPLANATION OF PLATE

Fig. 1. Smooth rock bed of Wailuku River, above Rainbow Falls, Hilo, Hawaii, habitat of *T. torrenticola* (Terry). Fig. 2. Swift-flowing rock-lined ditch at Waianae, Oahu, receiving water from Mt. Kaala, habitat of *T. williamsi*, sp. n. Fig. 3. Rocky seacoast at Waimanalo, Oahu, habitat of *T. pacificus* Tokunaga. Fig. 4. Surf-drenched boulders on seacoast near Waimea, Oahu, habitat of *T. pacificus*, Tokunaga. Fig. 5. Sloping wave-polished coral beach at Maile, Waianae, Oahu, habitat of *T. pacificus* Tokunaga. Fig. 6. Algae-covered wave-washed boulders on shore of Hilo Bay, Hawaii, habitat of *T. japonicus* Tokunaga and *T. pacificus* Tokunaga.

6. Marine **australicus** Womersley.
Fresh-water species (posterior pseudopods each with 20-23 hooks)
..... **williamsi** sp. n.
7. Median tooth of mentum broad and rounded distally.....
..... **torrenticola** (Terry).
..... **fluviatilis** sp. n.
Median tooth of mentum narrow, pointed distally.....
..... **abnormis** (Terry) (in part).
(Position of larvae of *T. sancti-pauli* and *minor* uncertain in above key;
larvae of *simplicipes*, *pusillum*, and *trochanteratum* unknown.)

Pupae:

- | | |
|--|------------------------------|
| 1. Denticles of rim of posterior sclerite of terminal abdominal disc each with a tuft of many fine yellow hairs (fig. 3a, b)..... | 2 |
| Denticles of rim of posterior sclerite of disc each with a single fine yellow hair (fig. 6g)..... | <i>pacificus</i> Tokunaga. |
| 2. Anterior cephalic margin bilobate mesad; terminal disc of abdomen elongate, transverse suture at about dorsal sixth..... | 3 |
| Anterior cephalic margin broadly rounded, not bilobate; terminal abdominal disc rounded, slightly ovate, suture at dorsal fourth..... | 4 |
| 3. Spiracle at proximal fourth of respiratory lobe; preapical abdominal segments with basal areas of clear shagreening..... | <i>sancti-pauli</i> Schiner. |
| Spiracle at proximal third of lobe; abdomen without shagreening on basal portion of segments..... | <i>minor</i> (Kieffer). |
| 4. Preapical abdominal segments with a prominent patch of yellowish brown shagreening on one or more segments..... | 5 |
| Abdominal shagreening fine and colorless..... | <i>williamsi</i> sp. n. |
| 5. Seventh abdominal tergite anterior to disc without large brown shagreened patch..... | 6 |
| Seventh abdominal tergite with a large brown shagreened patch covering most of tergite; spiracle about midway of lobe..... | <i>abnormis</i> (Terry). |
| 6. Third abdominal sternite with a prominent brown shagreened patch midway of basal sclerotized line; first tergite without large brownish shagreened area; abdominal vestiture of minute hairs.... | 7 |
| Third sternite without brown shagreened patch; first tergite almost covered with brown shagreened area; abdominal vestiture of prominent black hairs; (terminal disc with two prominent brown longitudinal impressed lines)..... | <i>hirtus</i> sp. n. |
| 7. Face of terminal abdominal disc with rough pebble-grained sculpturing and a median area of fine tubercles or spinules..... | 8 |
| Face of terminal disc without pebble-grained sculpturing or tubercles, quite smooth; rim of disc lightly sclerotized caudad..... | <i>fluviatilis</i> sp. n. |
| 8. Fresh-water species; about 10-13 hairs in submarginal area on ventral side of disc on each side of genital lobes..... | <i>torrenticola</i> (Terry). |
| Marine species; about 7 hairs on ventral side of disc on each side of genital lobes..... | <i>japonicus</i> Tokunaga. |
| (The pupae of <i>T. australicus</i> , <i>pusillum</i> , <i>simplicipes</i> , and <i>trochanteratum</i> are unknown.) | |

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REFERENCES

- Coquillett, D. W.
1900. "Papers from the Harriman Alaska Expedition. Entomological Results (3). Diptera." Proc. Washington Acad. Sci. 2: 389-464.
- Deby, J.
1889. "Description of a new dipterous insect, *Psamathomyia pectinata*." Jour. R. Microsc. Soc. 2: 180-186.
- Edwards, F. W.
1926. "On marine Chironomidae (Diptera); with descriptions of a new genus and four new species from Samoa." Proc. Zool. Soc. Lond., 51: 779-806.
1928. "A note on *Telmatogeton* Schiner and related genera." Konowia, 7: 234-237.
1931. "Chironomidae." Diptera of Patagonia and South Chile. Part 2, fascicle 3: 303-307. British Museum Publication.
1935. "Mycetophilidae, Culicidae, and Chironomidae, and additional records of Simuliidae from the Marquesas Islands." B. P. Bishop Mus. Bull. 114: 85-92.
- Hesse, A. J.
1934. "Contributions to a knowledge of S. African marine Clunione-Chironomids; (A) The early stages and ecology of *Telmatogeton sanctipauli* Schiner (*Trissoclunio fuscipennis* [Kieffer]) from the Cape Coast; (B) Early stages and ecology of *Telmatogeton minor* (Kieffer) and a redescription of the adults." Trans. R. Ent. Soc. Lond., 82: 27-40.
- Illingworth, J. F.
1931. "Insects in the Waiahole Ditch." Proc. Haw. Ent. Soc. 7: 408-409.
- Johannsen, O. A.
1905. "Aquatic Nematoceros Diptera II." Bull. N. Y. State Mus. 86: 76-327.
- Kieffer, J. J.
1911. "Description d'un Chironomide d'Amerique formant un genre nouveau." Bull. Soc. hist. nat. Metz, 27: 103-105.
1914. "South African Chironomidae." Ann. So. Afr. Mus., 10: 259-270.

1919. "Observations sur les Chironomides decrits par J. R. Malloch." Bull. Soc. ent. France, 1919: 191-194.
-
1920. "A new genus of chironomid (Diptera) from the Cape." Ann. So. Afr. Mus., 17: 523-525.
- Malloch, J. R.
 1915. "The Chironomidae or midges of Illinois." Bull. Ill. State Lab. Nat. Hist., 10: 400.
- Saunders, L. G.
 1928. "Some marine insects of the Pacific coast of Canada." Ann. Ent. Soc. Amer. 21: 521-545.
- Schiner, J. R.
 1866. "Bericht uber die von der Weltumseglungereise der K. Fregatte Novara mitgebrachten Dipteren." Verh. Zool. bot. Ges. in Wien 16: 927-934.
-
1868. "Diptera." Novara Reise, Zool. Bd. II, 388 pp.
- Terry, F. W.
 1913. "On a new genus of Hawaiian chironomids." Proc. Haw. Ent. Soc., 2: 291-295.
- Thienemann, A.
 1915. "Zur kenntnis der Salzwasser-Chironomiden." Arch. Hydrobiol., Supp. Bd. 2: 443-471.
- Tokunaga, M.
 1933. "Chironomidae from Japan (Diptera) I. Clunioninae." Philippine Jour. Sci., 51: 87-99.
-
1935. "Chironomidae from Japan (Diptera) IV. The early stages of a midge, *Telmatogeton japonicus* Tokunaga." Philipp. Jour. Sci., 57: 491-511.
-
1935. "Chironomidae from Japan (Diptera) V. Supplementary report on the Clunioninae." Mushi, Fukuoka, 8: 1-20.
-
1937. "Marine Diptera from the Danjo Islands." Biogeographica (Tokyo), 2: 34-38.
- Williams, F. X.
 1938. "Biological studies in Hawaiian water-loving insects, Part III. Diptera or Flies. B. Asteiidae, Syrphidae, and Dolichopodidae." Proc. Haw. Ent. Soc., 10: 281-315.
-
1944. "Biological studies in Hawaiian water-loving insects, Part III. Diptera or Flies. D. Culicidae, Chironomidae, and Ceratopogonidae." Proc. Haw. Ent. Soc., 12: 149-180.
- Womersley, H.
 1936. "An interesting chironomid, *Telmatogeton australicus* sp. n. from a South Australian reef." Rec. So. Australian Mus., 5: 439-443.

A. New *Phanerostethus* from the New Hebrides
(Coleoptera: Curculionidae)

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It is always of interest to add to our knowledge of the geographical distribution of any group of organisms, and it is with considerable satisfaction that I record the presence of the cryptorhynchine weevil genus *Phanerostethus* Marshall, 1931, in the New Hebrides. The genus is now known to occur in the Society Islands, Samoa, Fiji, New Caledonia and the New Hebrides. In these *Proceedings*, 11 (2):235, 1942, I gave a check list of the seven described species and a map showing their distribution.

***Phanerostethus laffooni*, new species (fig. 1).**

Male. Derm reddish brown to black; scaling dense, appressed, concealing most of derm, almost entirely black except as follows: a conspicuous white patch between eyes; pronotum with a white, median, prescutellar patch, scales on extreme base (ventral part abutting elytra) with a brownish cast rather than black; scutellum with white scales; elytra with basal part of second intervals white scaled, a patch of white just before middle on interval seven, subapical callosities white scaled, and with a few inconspicuous paler or white scales elsewhere; legs with some white scales on bases of femora and apices of tibiae; mesosternal side pieces with white or pale scales; metasternum and abdomen with pale scales, brownish, whitish and white intermixed, pale scaling on metasternum extending laterally between coxae to elytra; setae black, brownish and white, femora with white setae predominating.

Head with scales on crown small, dense, honeycomb-like in arrangement, white scales between eyes large, flatly imbricated; interocular area depressed, with prominent, erect, subspindle-shaped setae along inner margins of eyes.

Rostrum with about eight rows of prominent, robust, erect, mostly clavate or subspatulate setae borne from coarsely punctured striae from base to antennal insertions; bare, alutaceous, closely punctured from antennae to apex; subequal in breadth at apex, and at interocular area, breadth at antennal insertions 10/11 that at apex.

Antennae with scape clavate, fully as long as first five funicular segments; first funicular segment not quite as long as following two combined, about twice as long as broad, about one-third broader than two; segment two about as long as three plus one-half of four; segments three and four subequal in length; five to seven successively broader; club somewhat longer than four preceding segments.

Prothorax about as long as broad, broadest at middle, expanded from base to middle and arcuate to the well-marked subapical constriction which is continued broadly across dorsum whose longitudinal dorsal contour is conspicuously sinuous; extreme base rising abruptly, and nearly vertically, well above base of elytra, dorsal contours of pronotum and elytra abruptly discontinuous; punctures coarse, close, their interstices forming a reticulate pattern where exposed by abrasion of scales; squamae giving an incrustation-like appearance, excepting those in median, basal white patch which are larger and more discrete; setae conspicuous, erect, stout, peg-like, clavate or subclavate, numerous overall.

Elytra (measured from side) four units long as compared with two and one-half for prothorax, three units wide at widest part in basal quarter; base subtruncate, subcordate in lateral outline, strongly convex in longitudinal dorsal outline, highest at about basal three-eighths and there not as high as highest point on pronotum; subapical calli moderately well developed; striae well defined, coarsely punctured basad, more deeply impressed basad, thus giving intervals a more convex appearance there, striae six and seven not reaching base, ten not reaching middle of metacoxa; all intervals with a single row of prominent erect setae similar to those on pronotum, or somewhat longer, excepting interval two which has a double row beginning at about summit and running not quite half way down declivity, the interval more elevated and more convex in this region, intervals three and four distinctly nodiform at extreme base and with two and four less distinctly protuberant in holotype, interval one less convex than others in basal half; squamae appressed, giving an incrustation-like appearance.

Legs densely squamose and with numerous erect and slanting setae; inner sides of tibiae on male holotype with numerous hair-like setae, somewhat more conspicuous on fore pair.

Sternum with pectoral canal densely squamose in prosternal section, almost entirely bare between fore and mid coxae, squamose only at sides behind fore coxae; mesosternal receptacle with side walls high and well developed, but sloping back to level of metasternum at middle, densely squamose on outer sides and margins bearing conspicuous, sublanceolate setae, terminating at about middle of mesocoxae in male holotype; metasternum broadly concave, densely squamose and setose, as long along median line as abdominal segments three plus four.

Venter densely squamose, scales mostly moderately large and individually distinct, not closely appressed as on dorsum; setae numerous, conspicuous and scattered on ventrites one, two and five, mostly indistinct on three and four, longer, decurved and especially distinct on disc of one which is broadly and distinctly concave in male holotype, almost as long along median line as ventrites two to four inclusive plus about one-third of five.

Length: 3.25 mm.; breadth: 1.5 mm.

New Hebrides. Holotype male collected on Espiritu Santo Island, "VI-VIII-1944," by Jean Laffoon while on duty with a United States naval force in the New Hebrides; deposited in Bishop Museum.

This species is distinctly separated from the only other two species in the genus with which it might be associated because of its black scaling—*niger* Zimmerman from New Caledonia and *vitiensis* Zimmerman from Fiji—because of a number of well marked differential characters. The conspicuous, irregular, longitudinal, dorsal contour alone will serve to separate this species from *niger*. The contour is rather similar to that of *vitiensis*, but the different color



Fig. 1. Lateral and dorsal views of holotype male of *Phanerostethus lafooni* Zimmerman, new species.

pattern of the dorsal scaling will serve as an easily seen character to separate these two species. The white basal patch on the pronotum, the lateral submedian white patches on the elytra and the white subapical calli stand out plainly against the black background scaling, even to the naked eye. The setae on the second elytral intervals tend almost toward forming a very loose, vague, elongate fascicle, because of their greater numbers. Those on the fourth interval also vaguely suggest condensation.

It gives me much pleasure to dedicate this fine new species to Jean Laffoon in recognition of his active interest in collecting in the New Hebrides and for his generous gifts of specimens to Bishop Museum.